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Ms. Lori Wenkert  
South Florida Water Management District  
3301 Gun Club Road  
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Subject: Phase 2 Interim Report (April 2000 to December 2000) on the PSTA Research and Demonstration Project (C-E8624)

Dear Lori:

We are enclosing six (6) copies of the referenced document along with an additional camera-ready copy that the District can use to make internal copies should the need arise. Also enclosed is a CD containing the entire report in Adobe® Acrobat format. This report is the finalized version of the draft submitted in June 2001, and provides an interim summary of the data collected from the PSTA Test Cells during the study period of April 2000 to December 2000. As you are aware, Porta-PSTA research was completed in October 2000 and detailed in the prior interim report. The enclosed report also provides a description of the PSTA forecast model development to date. As discussed, a more detailed data analysis will be presented in the Phase 2 final report.

Copies of this document are being sent to the four members of the PSTA Scientific Review Panel: Ramesh Reddy, Bob Wetzel, Jan Stevenson and Jan Vymazal. In addition, we are forwarding copies to Frank Nearhoof and Taufiqal Aziz at the Florida Department of Environmental Protection, Nick Aumen at the National Park Service, Ron Jones at FIU (c/o Evelyn Gaiser), Bob Kadlec and Bill Walker. These additional copies will be shipped by the end of this week.

As always, should any questions arise regarding the enclosures, please feel free to call.

Sincerely,

CH2M HILL

A handwritten signature in blue ink that appears to read "Steve".

Steven W. Gong  
Project Manager

DFB/16806.doc

c: Jana Newman/SFWMD  
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eriphyton-Based Stormwater  
Treatment Area (PSTA) Research  
and Demonstration Project  
Phase 2 Interim Report  
(April 2000 - December 2000)

*Prepared for*

**South Florida Water Management District**

*Prepared by*

**CH2MHILL**

July 2001

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# Abbreviations and Acronyms

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$\mu\text{g/L}$	microgram(s) per liter
AFDW	ash-free dry weight
B	periphyton biomass
$B_a$	biomass accretion
$B_e$	biomass export
$b_g$	biomass growth
$b_r$	biomass respiration rate
$C_{\text{atm}}\text{TP}$	TP in rainfall
$C_{\text{in}}\text{TP}$	TP inflow concentration
cm	centimeter(s)
cm/s	centimeter(s) per second
CR	community respiration
District	South Florida Water Management District
DMSTA	dynamic stormwater treatment area
DO	dissolved oxygen
DOP	dissolved organic phosphorus
DRP	dissolved reactive phosphorus
EAA	Everglades Agricultural Area
E	Einstein
ENR	Everglades Nutrient Removal
ET	evapotranspiration
ft	foot (feet)
$\text{g/m}^2$	gram(s) per square meter
gpm	gallon(s) per minute
GPP	gross primary productivity
H	harvesting coefficient
Ha	hectares
HLR	hydraulic loading rate
in	inch (inches)
$K_a$	rate of biomass accretion
$K_e$	biomass export rate constant
kg	kilogram(s)
$K_l$	P release from labile storage rate constant

# Abbreviations and Acronyms (continued)

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$K_{net}$	TP net settling rate
$K_r$	biomass respiration rate constant
$K_{si}$	half saturation constant for PAR
$K_{sp}$	half saturation constant for TP
$K_u$	luxury uptake constant
m/y	meter(s) per year
mg/kg	milligram(s) per kilogram
MJ/M <sup>2</sup> /d	megajoules per square meter per day
mt/ha	metric tonnes per hectare
mt/ha/yr	metric tonnes per hectare per year
NPP	net primary productivity
O <sub>2</sub> /m <sup>2</sup> /hr	oxygen per square meter per hour
P	phosphorus
PAR	photosynthetically active radiation
P <sub>atm</sub>	bulk atmospheric deposition
P <sub>B</sub>	TP in biomass
P <sub>gw</sub>	TP in groundwater exchange
P <sub>in</sub>	TP in pumped inflow
P <sub>I</sub>	TP input from initial labile storage
P <sub>L</sub>	initial labile TP
POR	period of record
P <sub>out</sub>	TP in surface outflow
ppb	part(s) per billion
P <sub>r</sub>	TP returned to water column from biomass/sediments
PSTA	periphyton-based stormwater treatment area
P <sub>u</sub>	TP uptake by biomass growth and luxury uptake
P <sub>w</sub>	water TP
Q <sub>in</sub>	inflow
SAV	submerged aquatic vegetation
SRP	Scientific Review Panel
STA	stormwater treatment area
STSOC	Supplemental Technology Standards of Comparison
SWDI	Shannon-Weaver Diversity Index
TC	Test Cell
TDP	total dissolved phosphorus

## **Abbreviations and Acronyms (continued)**

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TIP	total inorganic phosphorus
TIS	tanks-in-series
TKN	total Kjeldahl nitrogen
TOP	total organic phosphorus
TP	total phosphorus
TPP	total particulate phosphorus
TSS	total suspended solids
VSS	volatile suspended solids
W	water column
W <sub>et</sub>	evapotranspiration
W <sub>in</sub>	pumped inflow
W <sub>out</sub>	applicable weir equation
W <sub>r</sub>	rainfall
W <sub>gw</sub>	seepage rate

# Executive Summary

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The South Florida Water Management District (District) is conducting research focused on potential advanced treatment technologies to support reduction of phosphorus (P) loads in surface waters entering the remaining Everglades. Periphyton-based stormwater treatment areas (PSTAs) are one of the advanced treatment technologies being investigated by the District.

Studies have been conducted in three of the south ENR Test Cells (PSTA Test Cells) and in 24 portable STA mesocosms (Porta-PSTAs). Phase 1 of this project began in the spring of 1999 and ended in March 2000. Information collected during that project period was summarized in the *Phase 1 Summary Report* (CH2M HILL, August 2000). Phase 2 of the project included continuing monitoring of the 27 mesocosms operated during Phase 1. Based on Phase 1 data analysis and input from the STA Scientific Review Panel (SRP), some of the Phase 1 treatments were continued unchanged into Phase 2, while other new treatments replaced the other Phase 1 treatments. Phase 2 research in the STA Test Cells ended in March 2001. Phase 2 research in the Porta-PSTAs ended in early October 2000. Supplemental mass balance (destructive) sampling of selected Porta-PSTA mesocosms was conducted in February 2001, and results will be reported in the project final report. Phase 2 research also will be conducted in pilot-scale mesocosms currently under construction (Field-Scale PSTAs). Construction is expected to be complete and operations started at this mesocosm level by mid-2001.

The STA Test Cell treatments were modified at the end of Phase 1 as follows:

- Average water depth was dropped in all three treatments from 60 to 30 centimeters (cm)
- Volunteer emergent macrophytes (primarily cattails and hydrilla) were removed from the peat-based cell (STC-4), and the peat was amended with calcium hydroxide to attempt to trap P fluxing from the peat soils during system startup after re-flooding
- A new water regime was established in one of the two shellrock treatments (STC-6) to provide a full dryout of the plant communities and sediments

No change other than the lowered water depth was made in the remaining shellrock soil STA Test Cell (STC-5).

Phase 2 data for the STA Test Cells and Porta-PSTAs were reported previously in the Phase 2 interim report for the study period of April–October 2000 (CH2M HILL, May 2001). Because Phase 2 Porta-PSTA data were presented in this interim report, the (data) analysis specific to these mesocosms is not repeated in this interim report. This report provides an interim summary of STA Test Cell data collected during the first 9 months of Phase 2 (April–December 2000). A more detailed analysis of STA Test Cell and Porta-PSTA data for the study period of April–October 2000 will be presented in the final project report. Interim Phase 2 findings for the STA Test Cells for the study period of April–December 2000 are summarized as follows:

- Total incoming solar radiation averaged 19.0 megajoules (MJ) per square meter per day ( $m^2/d$ ) for the period, and photosynthetically active radiation (PAR) averaged 30.3 mols of photons per  $m^2/d$ . Sunlight inputs are clearly seasonal based on the latitude and the presence of cloud cover.
- The total rainfall was 90.6 cm (35.7 in), which is equal to approximately 0.33 cm/d (0.13 in/d), while estimated evapotranspiration (ET) was 110 cm (43.5 in), or 0.40 cm/d (0.16 in/d). A slight net ET water loss of 0.07 cm/d (0.03 in/d) to the atmosphere from the PSTA mesocosms was estimated.
- The average total phosphorus (TP) inflow concentration was approximately 23 micrograms per liter ( $\mu g/L$ ) at the PSTA Test Cells. On average, this TP was approximately 48 percent particulate. The remaining dissolved fraction was typically approximately half dissolved organic phosphorus (DOP).
- Higher TP treatment performance was typically demonstrated by shellrock soil Test Cell treatments. The lowest average TP outflow concentration (based on all weekly values) for this research phase (12  $\mu g/L$ ) was achieved by the shellrock Test Cell treatment STC-5, with stable water regime. The average TP outflow concentration for the period was 30  $\mu g/L$  for the peat soil Test Cell treatment (STC-4) and 14  $\mu g/L$  for the variable-depth shellrock treatment (STC-6).
- From April to December 2000, the highest average TP one-parameter removal rate constant ( $k_{ITP}$ ) was measured in the variable water regime shellrock Test Cell at 16 meters per year (m/y). There was no apparent detrimental effect of dryout on outflow TP concentration. The value for  $k_{ITP}$  rose quickly following re-flooding and remained relatively high until a second dryout began in September 2000.
- Peat-based PSTA mesocosms achieved an average  $k_{ITP}$  value of approximately 5.8 m/y during the last 6 months of this Phase 2 interim period, and the stable water regime shellrock treatment had a  $k_{ITP}$  of 13.7 m/y during this same period.
- Soil disturbance in the peat-based PSTA Test Cell prior to the beginning of Phase 2 resulted in elevated TP outflow concentrations and negative mass removals following system startup for Phase 2. This disturbance was a result of plant removal and addition of hydrated lime intended to reduce the release of soluble P. Operational data for this study period did not demonstrate a benefit of lime addition at the Test Cell scale.
- Concentration trends for P in PSTA soils showed little change. Although average Phase 2 TP concentration in the shellrock soil was higher than in the peat soils (819 milligrams per kilogram [mg/kg] compared to 249 mg/kg), the labile inorganic P concentration in the peat soils is much higher than in the shellrock soils (24 mg/kg compared to 3 mg/kg). This difference is likely the cause of the continuing release of soil P to the water column in the peat-soil Test Cell and the resulting higher outflow TP concentration and lower  $k_{ITP}$  for this cell.
- A total of 117 different algal taxa were identified in PSTA Test Cell periphyton samples. Dominant algal taxa were in the blue-green (Cyanophyceae), diatom (Bacillariophyceae), and green (Chlorophyta) algal groups. The highest algal biovolumes were measured in the constant water regime Test Cell treatments.

- Average periphyton dry weight biomass varied from a low of 286 grams per square meter ( $\text{g}/\text{m}^2$ ) in the dry-down PSTA Test Cell (STC-6) to 1,044  $\text{g}/\text{m}^2$  in the calcium-amended peat Test Cell (STC-4). Ash-free dry weight (AFDW) biomass varied from 97  $\text{g}/\text{m}^2$  to 340  $\text{g}/\text{m}^2$  for these two extremes.
- Average periphyton corrected chlorophyll *a* ranged from 131 to 231 milligrams per square meter ( $\text{mg}/\text{m}^2$ ). Pheophytin estimates were typically highest in the peat mesocosms, indicating that these periphyton communities have a greater fraction of senescing algae than the other treatments.
- Average periphyton calcium content ranged from 87 to 210  $\text{g}/\text{m}^2$ , with the highest amount of periphyton calcium in the peat treatment. Average periphyton total Kjeldahl nitrogen (TKN) mass ranged from approximately 3.9 to 7.4  $\text{g}/\text{m}^2$ .
- Average periphyton TP concentration ranged from 247  $\text{mg}/\text{m}^2$  in the constant water regime shellrock treatment to 641  $\text{mg}/\text{m}^2$  in the peat soil treatment. Monthly average periphyton TP concentrations ranged from approximately 300 to 1,700  $\text{mg}/\text{kg}$  in all treatments.
- Macrophyte populations were dominated by submerged aquatic vegetation (SAV) in STC-4 and STC-5, with average cover ranging from 71 to 84 percent. STC-6 had an average SAV cover of 28 percent during this period. Emergent macrophyte cover in the PSTA Test Cells averaged between 17 and 40 percent during this period. Total macrophyte biomass in the PSTA Test Cells averaged between 135 and 402  $\text{g}/\text{m}^2$ .
- Average gross primary productivity (GPP) ranged from 2.8  $\text{g O}_2/\text{m}^2/\text{d}$  in STC-4 to 4.7  $\text{g O}_2/\text{m}^2/\text{d}$  in STC-6. Community respiration (CR) rates were similar to GPP, resulting in average GPP/CR ratios between 0.95 and 1.01. These metabolism estimates indicate that there was a slightly negative net primary productivity (NPP) recorded in treatments STC-4 and STC-5 for this interim period. The dry-out treatment (STC-6) had a slight positive NPP during this same period.
- PSTA community metabolism was initially high during the summer months and declined substantially by early fall. The GPP for the dry-out PSTA Test Cell lagged behind the other two cells, with a seasonal maximum in August 2000 and a later decline in the fall. Lower GPP rates generally coincide with higher emergent macrophyte cover, illustrating the shading effect of the emergent plant species on the periphyton and SAV.

## SECTION 1

# Project Background

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## 1.1 Introduction

The South Florida Water Management District (District) is conducting research focused on potential advanced treatment technologies to support reduction of phosphorus (P) loads in surface waters entering the remaining Everglades. Periphyton-based stormwater treatment areas (PSTAs) are one of the advanced treatment technologies being investigated by the District. The PSTA concept was proposed for P removal from Everglades Agricultural Area (EAA) waters by Doren and Jones (1996) and further described and evaluated by Kadlec (1996, 1998) and Kadlec and Walker (1996). Prior to initiation of the District's PSTA project in July 1998, detailed research to evaluate treatment performance issues and the long-term viability of the PSTA approach to P reduction in EAA surface waters had not been performed.

The two phases of the PSTA Research and Demonstration Project are described in detail in the revised *PSTA Research Plan* (CH2M HILL, April 2001). In brief, the first phase of the study provided basic research data needed to better understand whether the PSTA concept should continue to be investigated as a part of the solution for Everglades restoration.

Phase 1 research was performed through field-based mesocosm experiments located within the District's Everglades Nutrient Removal (ENR) Project. Phase 1 PSTA studies were conducted in 24 portable PSTA mesocosms (Porta-PSTAs), and in three of the south ENR Test Cells. Phase 1 research was conducted between February 1999 and March 2000, and has previously been reported by CH2M HILL (August 2000).

Phase 2 of the PSTA Research and Demonstration Project began in April 2000. Based on the results of Phase 1, it was decided to extend the Porta-PSTA research by 6 months and to continue PSTA Test Cell research for a second year. Thus, Phase 2 includes continued research in the Porta-PSTAs and in the ENR Test Cells, as well as startup and operation of the Field-Scale PSTA demonstration cells located near Stormwater Treatment Area 2 (STA-2). Operation and monitoring of the Porta-PSTAs was completed in early October 2000. PSTA Test Cell operation and monitoring was completed in March 2001. Construction of the Field-Scale pilot PSTA cells will be complete by mid-2001.

This document is an interim report prepared under Task 10 of the PSTA study program contract held by CH2M HILL. It focuses on continuing research in the PSTA Test Cells for the Phase 2 study period from April to December 2000. Brief summaries of updated key findings are provided in Sections 2 (Phosphorus Removal Performance and Effectiveness) and Section 3 (Community Development and Viability). The final draft version of the PSTA Forecast Model is described in Section 4. Detailed Phase 2 PSTA Test Cell data summaries are included in the appendices as follows:

- Appendix A-Meteorological Data
- Appendix B-ENR PSTA Test Cell Data
- Appendix C-Data Trend Charts
- Appendix D-Key Date Summary

Detailed PSTA forecast model interim results are included in:

- Appendix E-Model Calibration Spreadsheets
- Appendix F-Phase 2 Model Results
- Appendix G-Model Simulation Output Graphs

## **1.2 Summary of Phase 2 PSTA Test Cell Experimental Design and Treatments**

Exhibit 1-1 provides a summary of the design criteria and treatments used for the PSTA Research and Demonstration Project, including both Phases 1 and 2. A more detailed description of the Phase 2 PSTA Test Cell treatments is provided below.

The District assigned three South ENR Test Cells to the PSTA Research and Demonstration Project. During final construction, substrate within these PSTA Test Cells was modified by the District by placing the following layers of substrate over the cell liner:

- **South Test Cell 13**-2.5 feet (ft) of sand surcharge plus 1.0 ft of shellrock (locally mined) plus 1.0 ft of peat (taken from area of STA 1W, Cell 5 – unflooded, former agriculturally worked lands)
- **South Test Cell 8**-3.5 ft of sand surcharge plus 1.0 ft of shellrock (locally mined)
- **South Test Cell 3**-3.5 ft of sand surcharge plus 1.0 ft of shellrock (locally mined)

Three treatments were tested in the Test Cells during Phase 1. In March 2000, the Test Cells underwent several operational design changes, such as soil amendments, water regime, and water depth. The treatments were renumbered for Phase 2, with monitoring beginning in April 2000 and continuing through March 2001.

Treatment STC-4 (South Test Cell 13) was amended with calcium to decrease the amount of soluble P being released from the peat soils. Average water depth was reduced from 60 to 30 centimeters (cm), and the target hydraulic loading rate (HLR) remained at 6 centimeters per day (cm/d).

Water depth in Treatment STC-5 (South Test Cell 8) was reduced to 30 cm.

The operation schedule for Treatment STC-6 (South Test Cell 3) was revised during Phase 2 to include two prolonged dryouts, a maximum HLR of 11.4 cm/d, a maximum operational water depth of 60 cm, and an average depth of approximately 30 cm. The outflow weir in South Test Cell 3 was dropped to its lowest level and the natural balance between rain and evapotranspiration (ET) was relied upon to provide a realistic dryout. There was no measurable water depth in this cell during most of the dryout periods.

Monthly average HLRs in the PSTA Test Cells during Phase 2 are summarized in Exhibit 1-2. Average monthly water depths are provided in Exhibit 1-3.

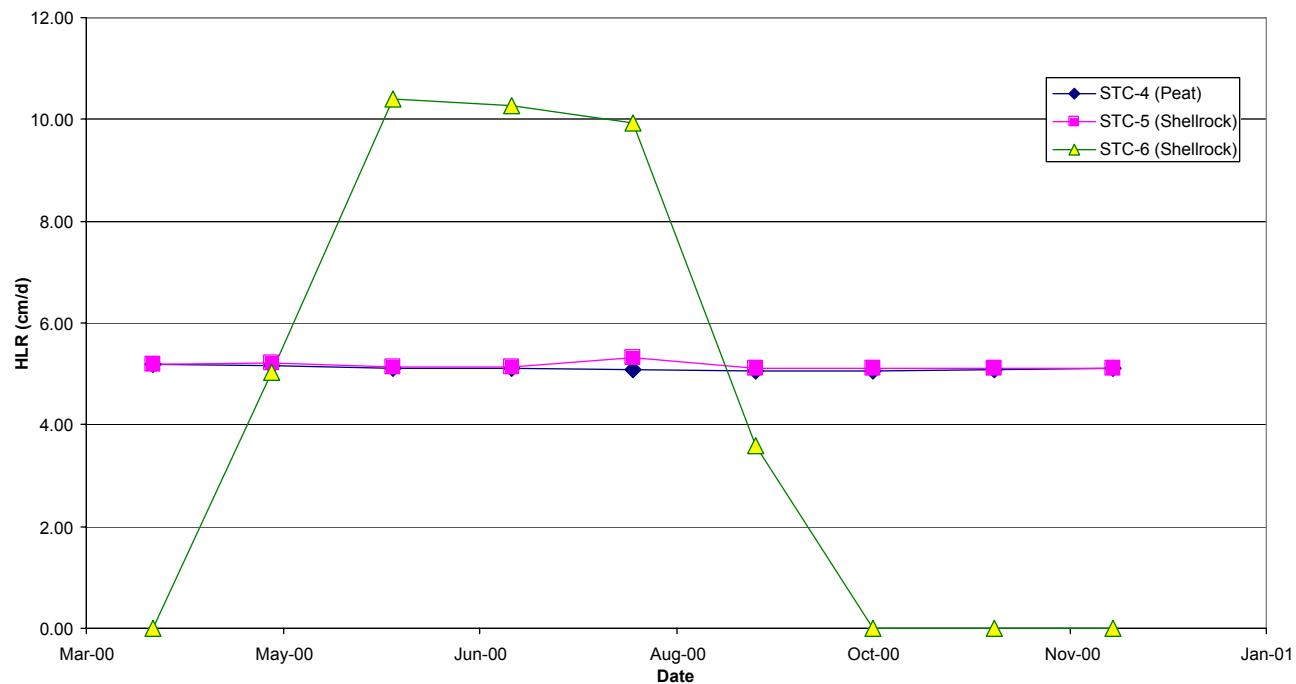
**EXHIBIT 1-1**

Comparison of PSTA ENR South Test Cell Phase 1 and Phase 2 Treatments

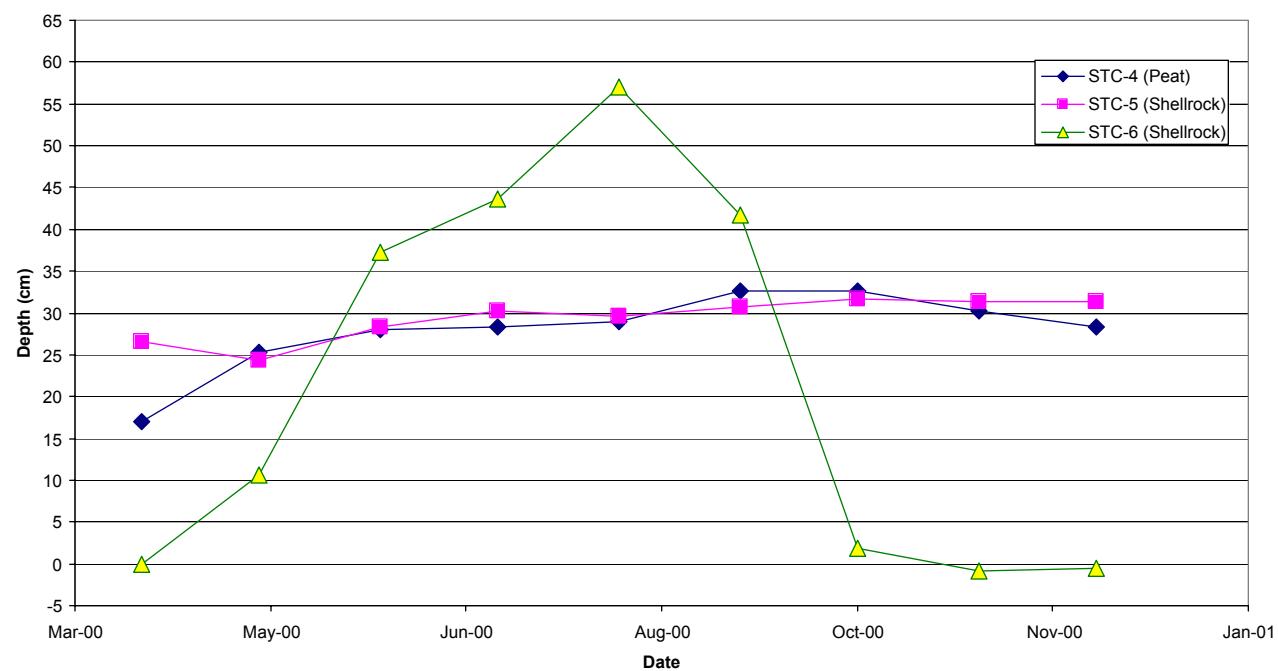
TC #	Phase 1 (February 1999 - March 2000)	Phase 1 to Phase 2 Alterations (March - April 2000)		Phase 2 (April 2000 - April 2001)
TC 13	<b>STC-1</b>			<b>STC-4</b>
	Substrate: Peat Depth: 60 cm HLR (cm/d): 6 Average Velocity (cm/s): 0.0093 Depth:Width Ratio: 0.02 Vegetation: Periphyton, <i>Eleocharis</i> , <i>Utricularia</i>	<ul style="list-style-type: none"> <li>Vegetation herbicided and removed</li> <li>Cell floor wetted and peat soil amended with lime (7 mt/ha)</li> <li>Cell reflooded, but operated at 30 cm</li> <li>Vegetation replanted</li> <li>Cell inoculated with periphyton</li> </ul>	Substrate: Peat + Ca Depth: 30 cm HLR (cm/d): 6 Average Velocity (cm/s): 0.0185 Depth:Width Ratio: 0.01 Vegetation: Periphyton, <i>Eleocharis</i> , <i>Utricularia</i>	
TC 8	<b>STC-2</b>			<b>STC-5</b>
	Substrate: Shellrock Depth: 60 cm HLR (cm/d): 6 Average Velocity (cm/s): 0.0093 Depth:Width Ratio: 0.02 Vegetation: Periphyton, <i>Eleocharis</i> , <i>Utricularia</i>	<ul style="list-style-type: none"> <li>Water depth reduced to 30 cm</li> <li>No other changes made</li> </ul>	Substrate: Shellrock Depth: 30 cm HLR (cm/d): 6 Average Velocity (cm/s): 0.0185 Depth:Width Ratio: 0.01 Vegetation: Periphyton, <i>Eleocharis</i> , <i>Utricularia</i>	
TC 3	<b>STC-3</b>			<b>STC-6</b>
	Substrate: Shellrock Depth: 0- 60 cm HLR (cm/d): 0- 12 Average Velocity (cm/s): 0.0093 0.02 Depth:Width Ratio: Vegetation: Periphyton, <i>Eleocharis</i> , <i>Utricularia</i>	<ul style="list-style-type: none"> <li>Two complete dry-outs scheduled for the cell with subsequent reflooding</li> <li>Maximum water depth of 30 cm</li> </ul>	Substrate: Shellrock Depth: 0- 30 cm HLR (cm/d): 0- 12 Average Velocity (cm/s): 0.0185 Depth:Width Ratio: 0.01 Vegetation: Periphyton, <i>Eleocharis</i> , <i>Utricularia</i>	

Note:

mt/ha = metric tonnes per hectare



**EXHIBIT 1-2**  
Average Monthly Inlet Hydraulic Loading Rates in the PSTA Test Cells, April—December 2000



**EXHIBIT 1-3**  
Average Monthly Water Depth in the PSTA Test Cells, April—December 2000

## **1.3 Environmental Forcing Functions**

External environmental forcing functions that have affected the growth and performance of the PSTA Test Cells include:

- Sunlight (measured as total insolation and photosynthetically active radiation [PAR])
- Rain inputs
- ET outputs
- Inflow P concentrations

The general history of each of these forcing functions for the Phase 2 period-of-record (POR) is presented in Exhibits 1-4 through 1-6. Detailed meterological data are provided in graphical form in Appendix A.

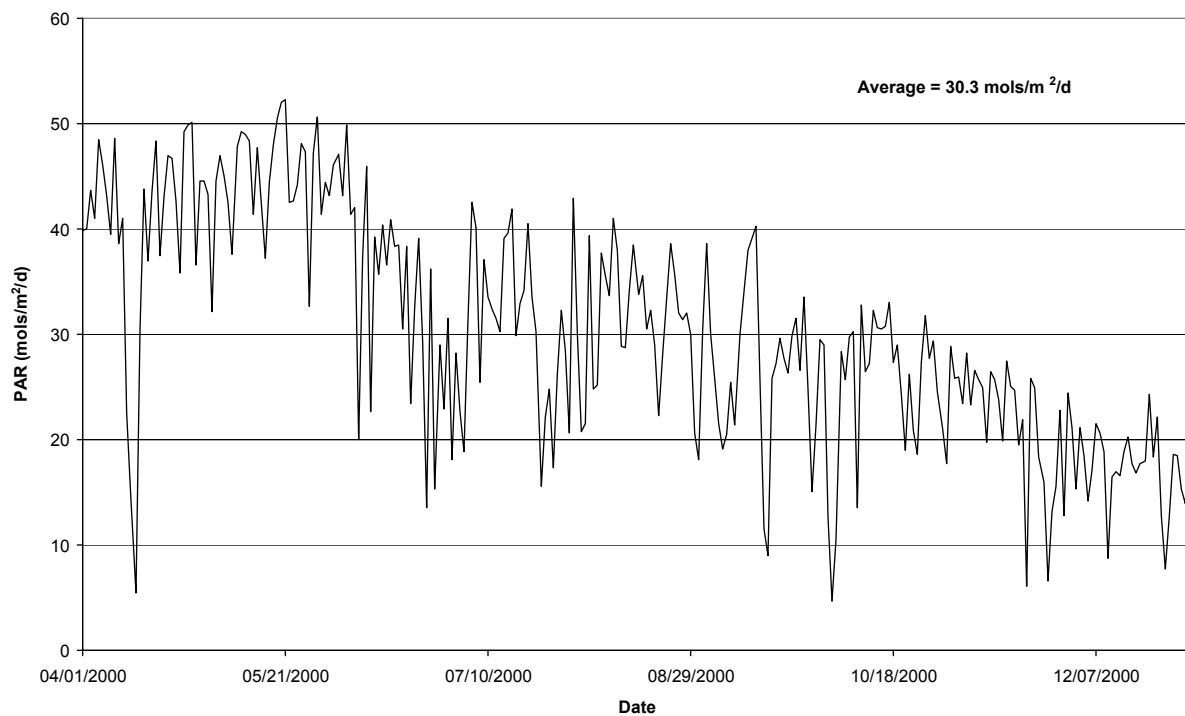
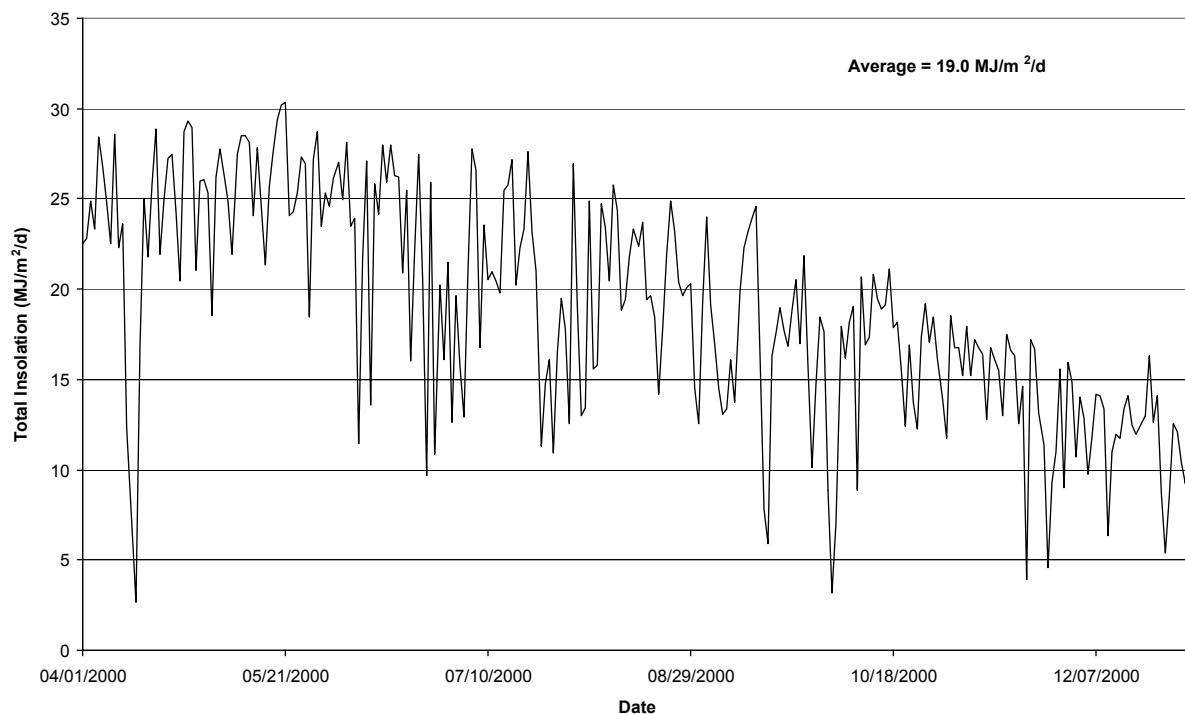
Exhibit 1-4 summarizes the total insolation and PAR received at the project site during the Phase 2 period. Total insolation (incoming solar radiation) averaged 19.0 megajoules (MJ) per square meter per day ( $m^2/d$ ), and PAR averaged 30.3 mols per  $m^2/d$ . Sunlight inputs are clearly seasonal based on the latitude and the presence of cloud cover.

Exhibit 1-5 compares the measured rainfall and estimated ET and their net difference. The total rainfall for the 274 day POR was 90.6 cm (35.7 inches [in]), which is equal to approximately 0.33 cm/d (0.13 in/d), while ET was 110 cm (43.5 in), or 0.40 cm/d (0.16 in/d). These data indicate that there was a slight net ET water loss to the atmosphere (0.07 cm/d [0.03 in/d]) from the PSTA mesocosms estimated during this Phase 2 research period.

Exhibit 1-6 summarizes the measured concentrations of total phosphorus (TP), total dissolved phosphorus (TDP), total particulate phosphorus (TPP), dissolved organic phosphorus (DOP), and dissolved reactive phosphorus (DRP) in the inflows to the PSTA Test Cells during Phase 2. The average Phase 2 TP inflow concentration was approximately 22.5 micrograms per liter ( $\mu g/L$ ). On average, this TP was approximately 48 percent particulate and the rest dissolved. The dissolved fraction was typically approximately half DOP. During August 2000, the majority of the measured TP was DRP.

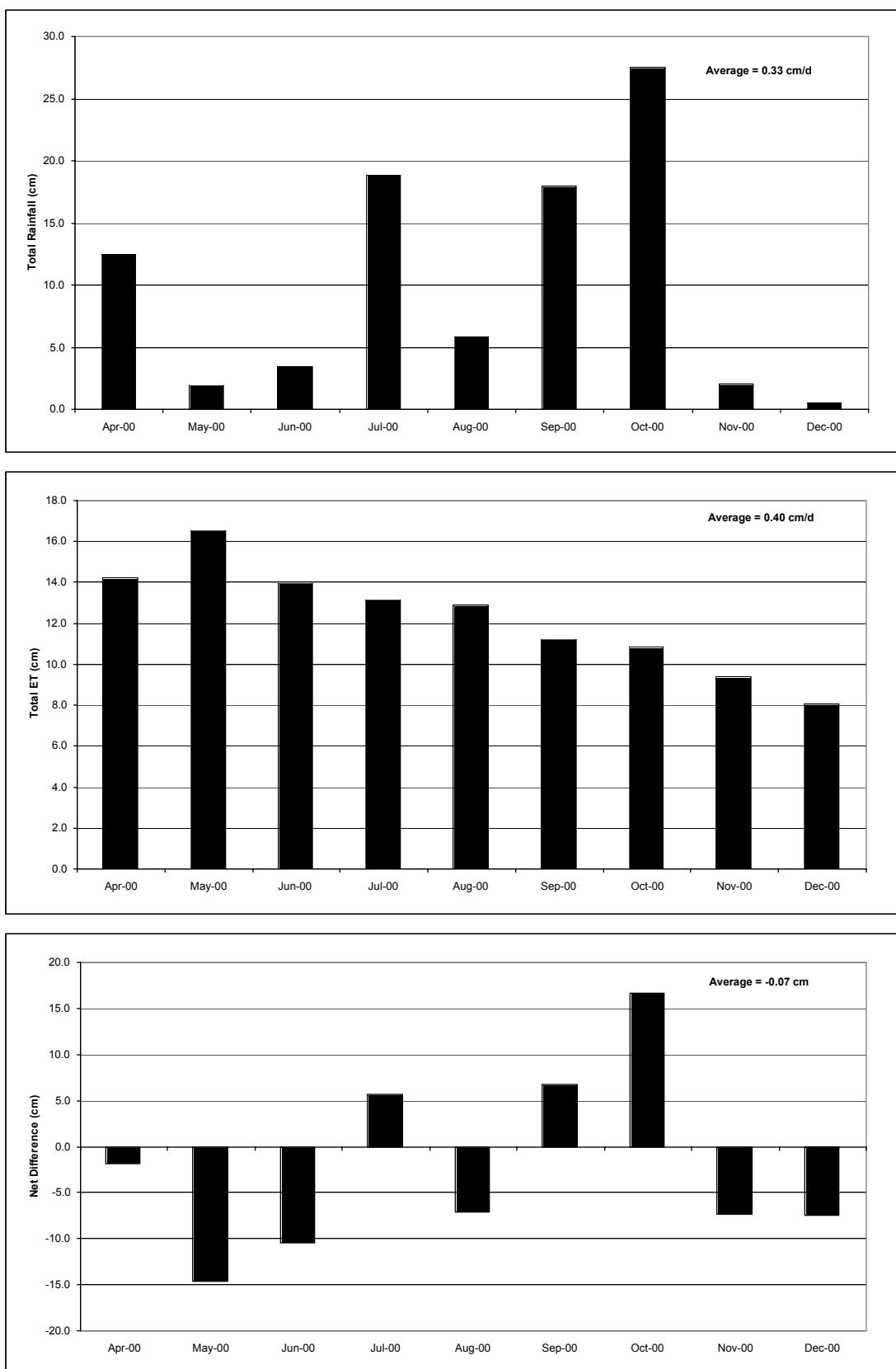
**EXHIBIT 1-4**

Solar Energy Inputs to the PSTA Mesocosms, April - December 2000



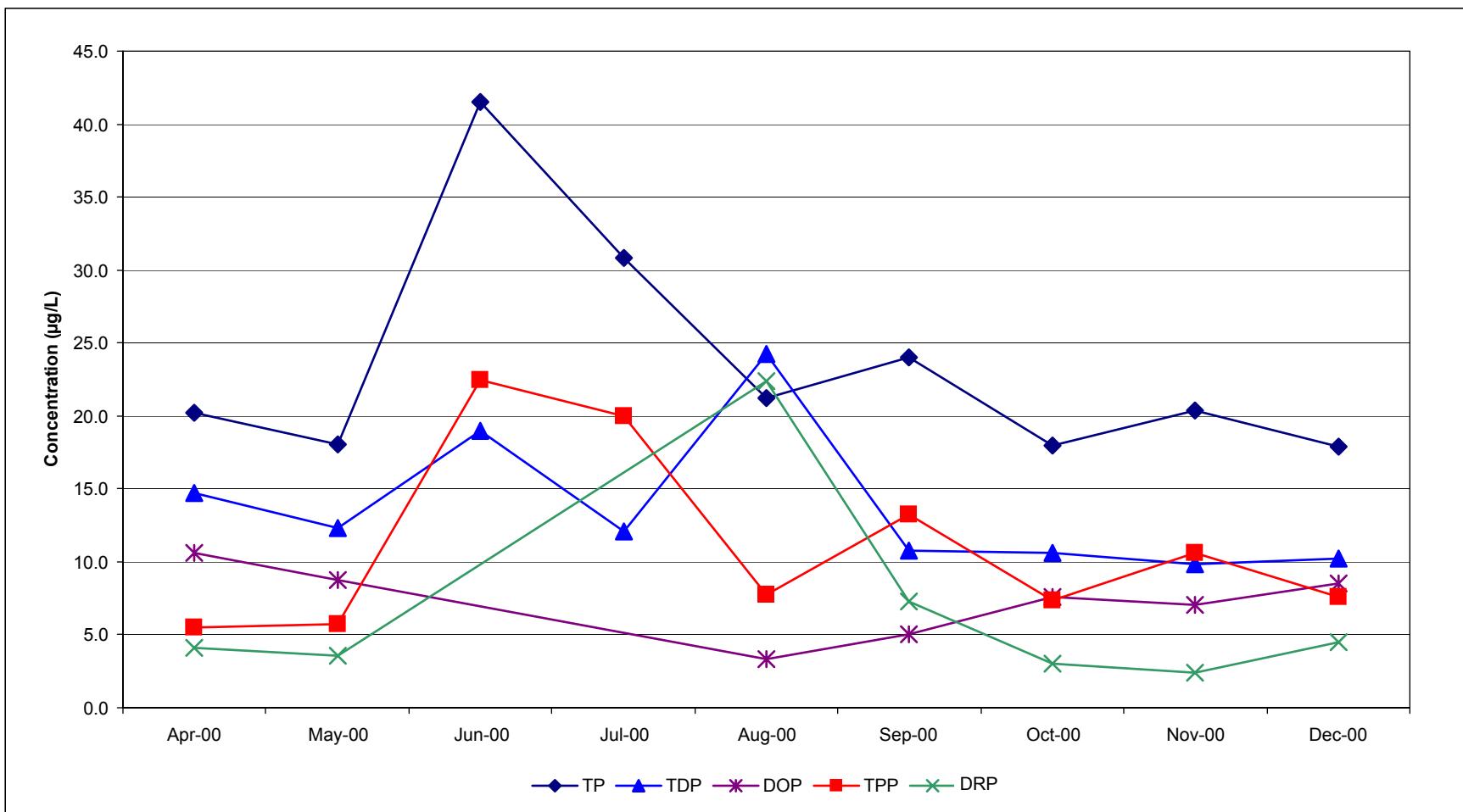
**EXHIBIT 1-5**

Rainfall and Evapotranspiration at the PSTA Mesocosms, April - December 2000



**EXHIBIT 1-6**

Input Concentrations of TP, TDP, TPP, DOP, and DRP in Source Water at the STC PSTA Site, April - December 2000



## SECTION 2

# Phosphorus Removal Performance and Effectiveness

---

## 2.1 Introduction

This section provides a summary of key findings for the PSTA Test Cell P treatment performance for Phase 2 from April through December 2000. Results are summarized to provide an interim status on PSTA effectiveness for TP concentration and mass reduction. Key issues addressed in this section include:

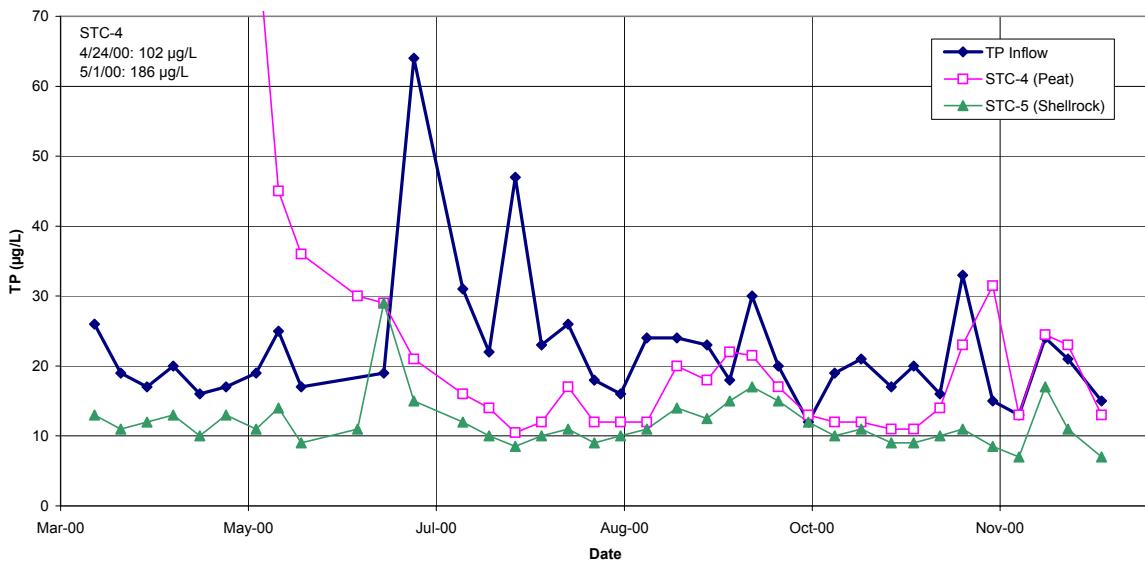
- TP concentration and  $k_{1TP}$  trends as a function of soil type and water regime
- Efficacy of calcium amendment of peat soils
- Soil P concentration trends

Detailed data supporting these summaries are included in Appendices B and C. A chronological listing of key project activities is provided in Appendix D. A more complete analysis and summary of all project findings will be provided in the PSTA Research and Demonstration Project final report.

## 2.2 TP Concentration and $k_1$ Trends

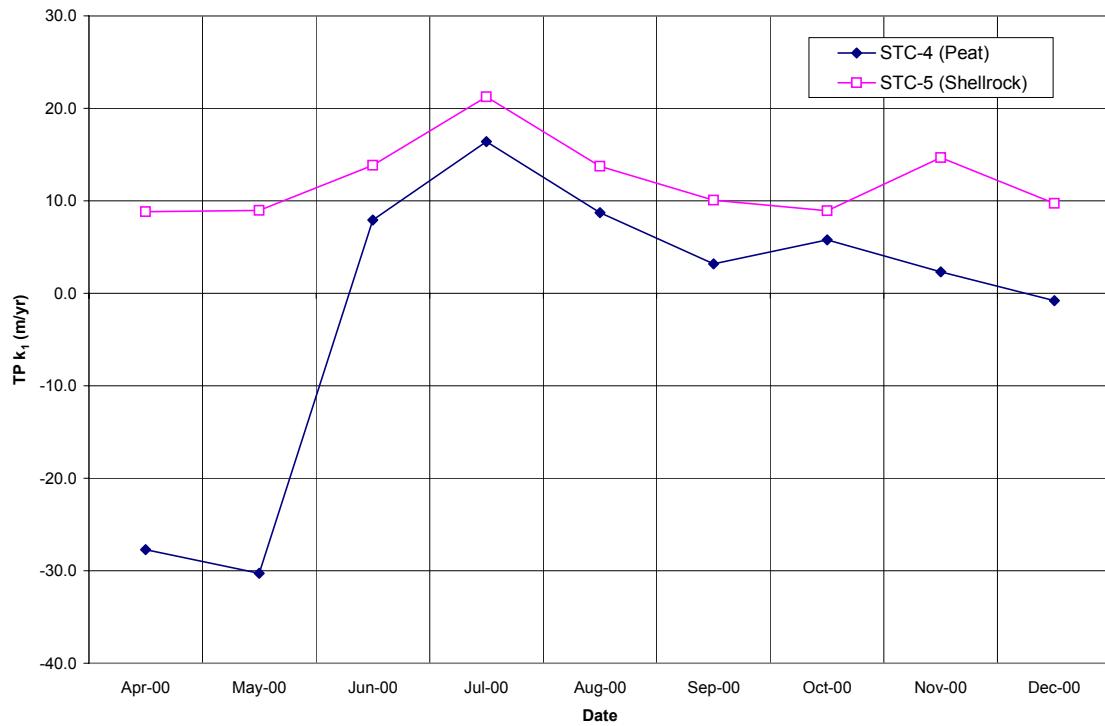
Exhibit 2-1 illustrates the TP time series data for the peat and shellrock PSTA Test Cell operated at constant depth and HLR rates. Average TP inflow concentration to these cells was approximately 23 µg/L for the study period. Treatment STC-5 (shellrock) continued its trend of low outflow TP concentrations with an average of 12 µg/L. Soil disturbance in STC-4 (peat) resulted in an immediate spike in outflow TP concentrations upon re-flooding despite the lime soil amendment. This concentration declined rapidly through most of the study period; however, average TP outflow concentration in STC-4 was 35 µg/L. The average TP outflow concentration from this test system had declined to 16 µg/L during the last 6 months of this Phase 2 interim period. It is noteworthy that TP concentrations in the STC-4 outflow were seasonally higher in the early fall and at the end of the year.

Exhibit 2-2 includes the  $k_{1TP}$  time series data for PSTA Test Cell treatments STC-4 and STC-5. TP removal rate constants have been consistently higher in the shellrock treatment than in the peat-based system during the study period. The  $k_{1TP}$  for the shellrock PSTA was relatively constant, while the TP removal rate constant for the peat PSTA system declined throughout the latter half of the study period to approximately zero in December 2000. Average  $k_{1TP}$  values for STC-4 and STC-5 were -7.2 and 12.6 meters per year (m/y), respectively. During the last 6 months of the Phase 2 interim period, the  $k_{1TP}$  values for STC-4 and STC-5 were 5.8 and 13.7 m/yr, respectively.



#### EXHIBIT 2-1

PSTA Test Cell TP Inflow and Outflow Concentrations in Treatments STC-4 (Peat) and STC-5 (Shellrock), April - December 2000



#### EXHIBIT 2-2

PSTA Test Cell  $k_{TP}$  Values in Treatments STC-4 (Peat) and STC-5 (Shellrock), April - December 2000

Exhibit 2-3 provides the TP time series for PSTA Test Cell treatment STC-6 (shellrock with variable water regime). This cell was in a dryout mode (no inflow with outlet weir lowered) from March 6 to May 18, 2000, and from September 13, 2001, until January 2001. For the Phase 2 interim period, average inflow TP concentration was approximately 24 µg/L, and the average outflow TP concentration for this treatment was 16 µg/L. There was no apparent detrimental effect of this spring dryout on outflow TP concentration. System treatment performance recovered to pre-drydown conditions within approximately 2 weeks of rehydration. Exhibit 2-4 illustrates the trend in  $k_{1TP}$  in the dry-down PSTA Test Cell treatment. The value for  $k_{1TP}$  increased quickly following re-flooding and remained relatively high until August 2000, before declining in September 2000. The average  $k_{1TP}$  for this cell was 12.0 m/y. The average value of  $k_{1TP}$  for the last 6 months of the Phase 2 interim period was 22.0 m/yr.

## 2.3 Efficacy of Calcium Amendment of Peat Soils

It was observed during Phase 1 that peat soils released labile P to the water column at a higher rate and for a longer period than the calcium-based shellrock soils (CH2M HILL, August 2000). Phase 2 PSTA research in these mesocosms was expanded to look at the effects of amending some of the peat (organic) soils with calcium minerals recommended by Ann et al. (2000). This section provides an updated evaluation of the data from the amended soil PSTA Test Cell treatment STC-4 (Test Cell 13).

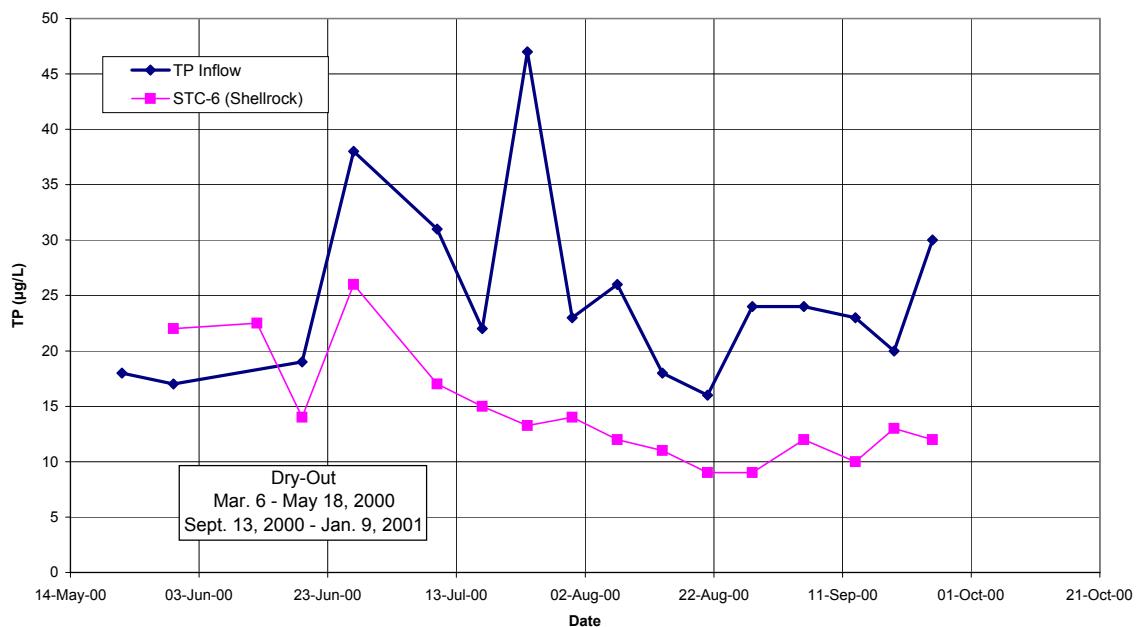
PSTA South Test Cell Treatment 1 (STC-1 or Test Cell 13) was converted to South Test Cell Treatment 4 (STC-4) by the addition of approximately 1,580 kilograms (kg) of hydrated lime [ $\text{Ca}(\text{OH})_2$ ], providing an effective application rate of 7 metric tonnes per hectare (mt/ha).

While the Phase 1 water depth in each of this cell had been 60 cm, the Phase 2 water depth was lowered to approximately 30 cm. The purpose of this depth change was to document the effects of consistently lower water depth on PSTA performance and periphyton growth. This change was recommended by the Scientific Review Panel (SRP) during the Phase 1 data review.

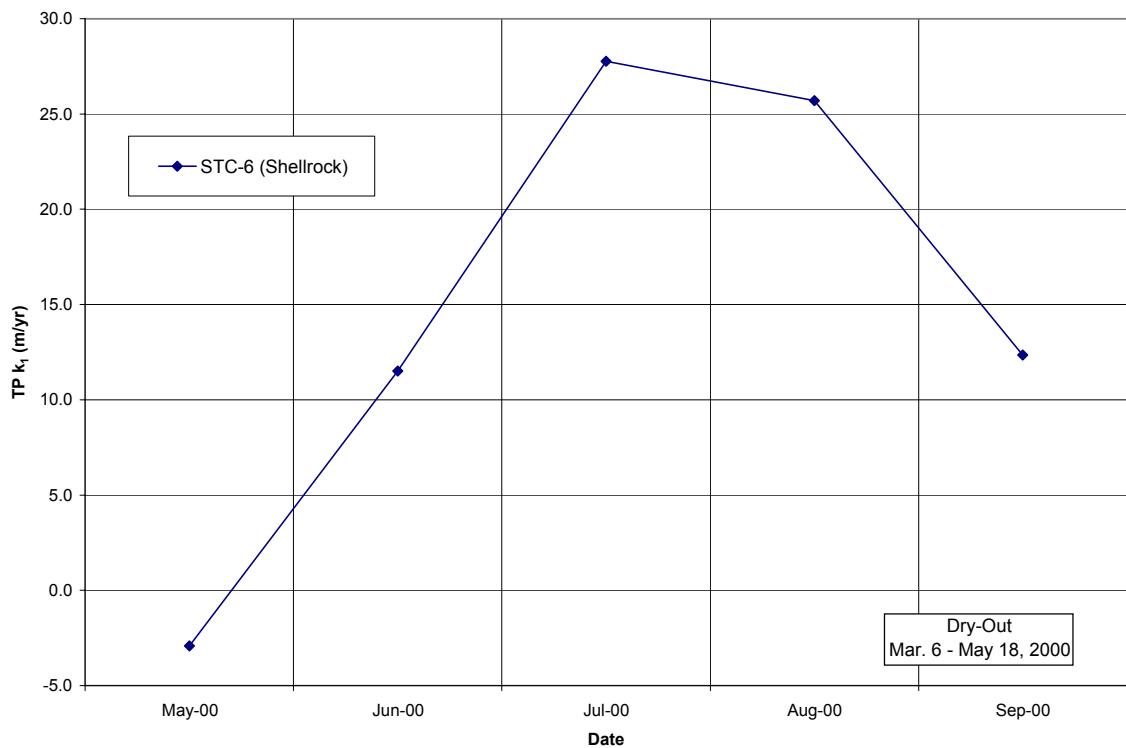
There was no control available to look at the effect of the water depth change alone. Data analysis includes a comparison between STC-1 and STC-4 averages before and after liming for a 270-day period during each research phase. Three comparisons were made:

- TP monthly average outflow concentrations were evaluated for the 9 months following flooding
- Cumulative TP removal was estimated for the 9 months following flooding
- Estimates of monthly average  $k_{1TP}$  values were made for each treatment for 9 months following flooding

In addition to the above analyses, these same three parameters were calculated for the last 60 days of each 6-month period. Exhibit 2-5 provides a tabular summary of these data analyses. Exhibits 2-6 and 2-7 provide graphical summaries of monthly TP outflow concentrations and cumulative TP mass removal, respectively.



**EXHIBIT 2-3**  
PSTA Test Cell TP Concentration Trends in STC-6 (Shellrock with Dry-down), April - December 2000

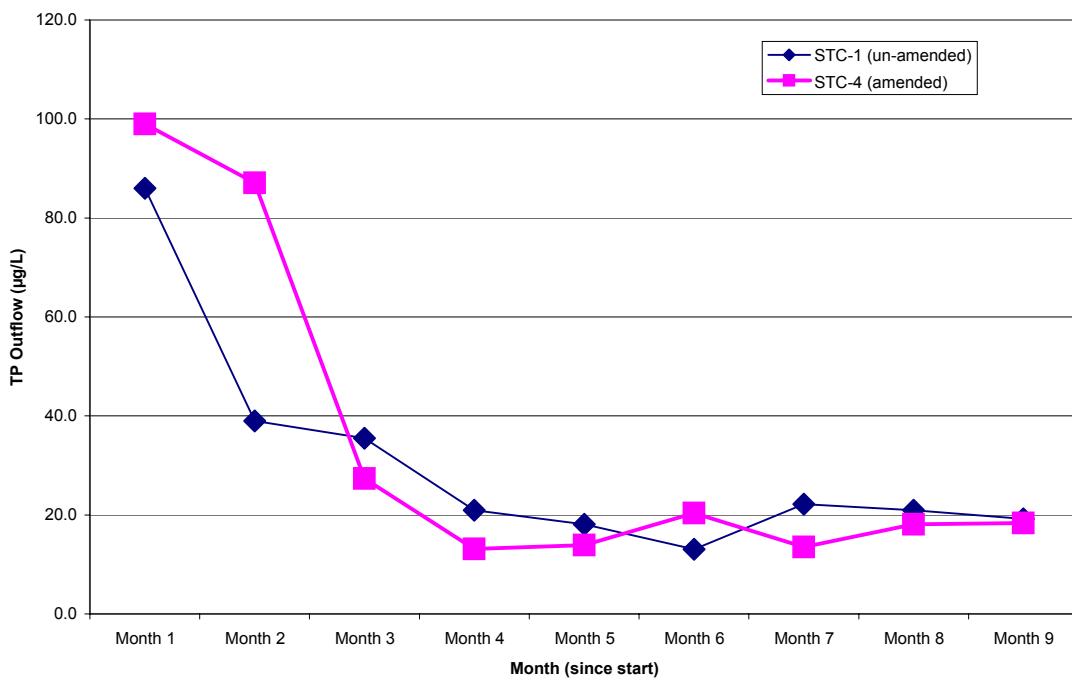


**EXHIBIT 2-4**  
PSTA Test Cell  $k_{1\text{TP}}$  Values in Treatment STC-6 (Shellrock with Dry-out), April - December 2000

**EXHIBIT 2-5**

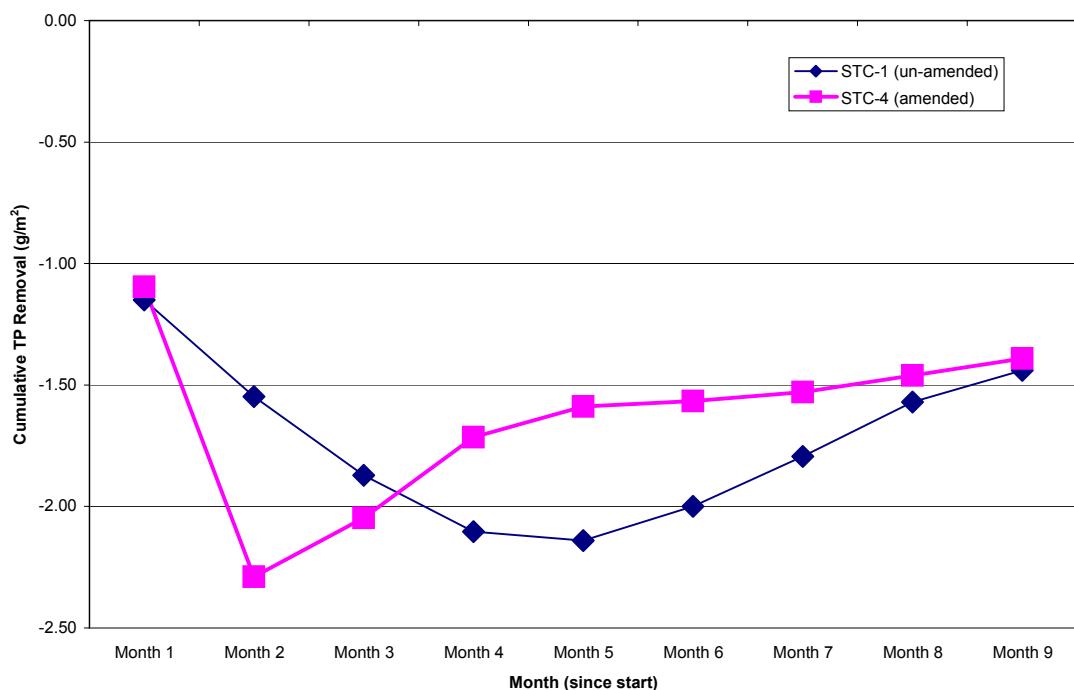
PSTA Amended Peat Soils Data Summary, April - December 2000

Treatment	Period	q_in (cm/d)	Wtr Depth (m)	TP (µg/L)		TP (g/m <sup>2</sup> )		Removal (g/m <sup>2</sup> )		Calc_k (m/y)
				Inflow	Outflow	Inflow	Outflow	Average	Cumulative	
STC-1 (Peat)	POR (270d)	4.6	0.63	25	31	0.42	0.58	-0.16	--	-3.5
	Last 60d	4.6	0.65	29	20	0.48	0.31	0.18	--	6.0
	Month 1	4.7	0.51	19	86	0.32	1.47	-1.15	-1.15	-26.2
	Month 2	4.4	0.65	20	39	0.31	0.71	-0.40	-1.55	-10.6
	Month 3	4.6	0.66	25	36	0.42	0.74	-0.32	-1.87	-5.7
	Month 4	4.7	0.63	20	21	0.35	0.58	-0.23	-2.10	-0.5
	Month 5	4.7	0.63	20	18	0.35	0.39	-0.04	-2.14	2.0
	Month 6	4.7	0.64	26	13	0.44	0.30	0.14	-2.00	11.6
	Month 7	4.7	0.64	35	22	0.60	0.40	0.21	-1.79	7.9
	Month 8	4.7	0.65	32	21	0.54	0.31	0.22	-1.57	7.0
	Month 9	4.5	0.66	26	19	0.43	0.30	0.13	-1.44	5.0
STC-4 (Peat Amended)	POR (270d)	5.1	0.28	23	35	0.44	0.59	-0.15	--	-7.2
	Last 60d	5.1	0.29	19	18	0.35	0.29	0.07	--	0.8
	Month 1	5.2	0.15	19	99	0.36	1.46	-1.10	-1.10	-31.2
	Month 2	5.2	0.25	18	87	0.33	1.52	-1.19	-2.29	-30.1
	Month 3	5.1	0.28	42	27	0.77	0.53	0.24	-2.05	7.8
	Month 4	5.1	0.28	31	13	0.58	0.25	0.33	-1.72	16.0
	Month 5	5.1	0.29	22	14	0.40	0.28	0.13	-1.59	8.4
	Month 6	5.0	0.33	24	20	0.44	0.42	0.02	-1.57	3.0
	Month 7	5.0	0.33	18	14	0.33	0.29	0.04	-1.53	5.3
	Month 8	5.1	0.30	21	18	0.38	0.32	0.07	-1.46	2.4
	Month 9	5.1	0.28	18	18	0.33	0.26	0.07	-1.39	-0.9



**EXHIBIT 2-6**

Average Monthly TP Outflow Concentrations in the PSTA Test Cells Peat Soil Treatments with and without Lime Amendments, April - December 2000



**EXHIBIT 2-7**

Cumulative TP Mass Removed in the PSTA Test Cells Peat Soil Treatments with and without Lime Amendments, April - December 2000

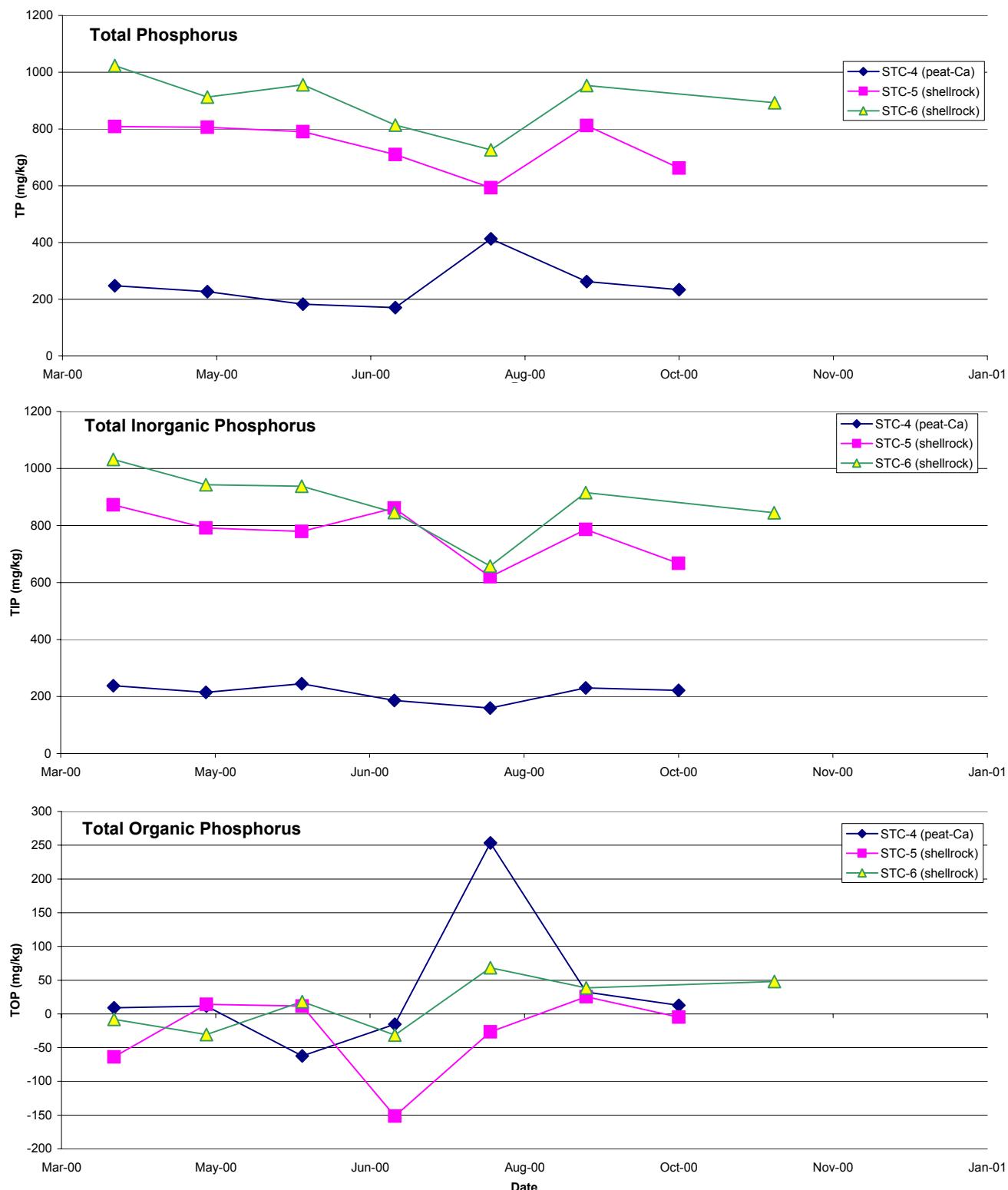
Average water depth in the peat-based PSTA cell (STC-1/STC-4) changed from 63 cm during Phase 1 to 28 cm in the Phase 2 study period. Average inflow TP concentrations to the Test Cells during each 270-day period were slightly higher in STC-1 than in STC-4 (25 and 23 µg/L, respectively), but average loads were slightly higher in STC-4 (amended) because of a higher HLR during this period. Average 9-month TP outflow concentrations were higher in STC-4 (amended) than in STC-1, at 35 µg/L and 31 µg/L, respectively. However, inflow and outflow concentrations during the final 60 days of each test were higher in Phase 1.

Exhibit 2-6 illustrates that TP outflow concentrations were initially high in both treatments and declined in a similar fashion, resulting in similar final concentrations. Cumulative TP removal during the 9-month POR was similar in both treatments (net release of 1.4 g TP/m<sup>2</sup>/y) (see Exhibit 2-7). The average  $k_{1TP}$  estimate for this 9-month POR was slightly higher in the treatment without the lime addition (see Exhibit 2-5). The higher value of  $k_{1TP}$  in treatment STC-1 during the final 60-day period is likely the result of the higher TP inflow concentration during that time. Based on these data, there does not appear to be a beneficial effect of the soil amendment on either the TP mass removal or attainable outflow TP concentration at the PSTA Test Cell scale.

## 2.4 Soil P Concentration Trends

Exhibit 2-8 illustrates the time series soil P data (upper 10 cm) for the PSTA Test Cells during the Phase 2 interim period. Appendices B-6 and B-7 provide detailed data for soil P concentrations and chemical forms. Concentration trends for TP, total inorganic phosphorus (TIP), and total organic phosphorus (TOP) were relatively stable during the Phase 2 interim period and continued with little change from Phase 1. TOP concentrations are estimated by the difference between TP and TIP; negative values indicate that very little TOP is typically present in these samples.

Although average Phase 2 TP concentration in the shellrock soils is much higher than in the peat soils (819 milligrams per kilogram [mg/kg] vs. 249 mg/kg, respectively), the labile inorganic P concentration in the peat soils summarized in Appendix B-7 is much higher (average 24 mg/kg compared to 3 mg/kg, respectively). This finding strengthens the Phase 1 report conclusion that there is a continuing potential for release of inorganic P from the organic soils in STC-4 (CH2M HILL, August 2000). While the mass release of labile P from these peat soils is probably too small to detect in the trend plots for total forms, it appears likely that this release contributes to the higher observed outflow TP concentration and the lower  $k_{1TP}$  value in this treatment.



#### EXHIBIT 2-8

Monthly Sediment TP, TIP, and TOP Concentrations in the PSTA Test Cells, April - December 2000

## SECTION 3

# Community Development and Viability

---

### 3.1 Introduction

One important aspect of evaluating the PSTA concept is developing a quantitative understanding of the ecological structure and function of the periphyton-dominated plant community. The PSTA Research and Demonstration Project monitoring includes a number of ecological parameters to provide a characterization of the viability of the PSTA ecosystem. These parameters include algal species identifications, biomass estimates, chlorophyll estimates, algal mat and emergent plant coverage, accretion rates of new sediments, and measures of community metabolism.

This section briefly summarizes Phase 2 interim data (April–December 2000) relevant to these PSTA viability issues. These analyses are preliminary and will be updated for the entire Phase 2 period in the final project report. Detailed biological data for the study period are provided in Appendix B.

### 3.2 Algal Taxonomic Composition

A total of 117 algal taxa were identified in PSTA Test Cell periphyton samples collected during the study period. Appendix B-11 provides detailed lists of the algal cell counts and monthly totals by individual taxa. A total of 89 algal taxa were recorded in STC-4, 62 taxa recorded in STC-5, and 73 taxa recorded in STC-6 during this Phase 2 interim period.

Exhibits 3-1 and 3-2 provide summaries of the PSTA Test Cell algal cell densities and biovolumes, respectively, by major taxa. Dominant taxa in all three PSTA Test Cells were in the blue-green (Cyanophyceae), diatom (Bacillariophyceae), and green (Chlorophyta) algal groups. The highest algal biovolumes were measured in the peat-based PSTA Test Cell (STC-4) in December 2000. Average algal biovolumes for the study period were similar in STC-4 and STC-5 and lower in the dry-out shellrock treatment (STC-6). The periphyton biovolumes in the shell-rock treatments typically had a higher proportion of diatoms than the peat treatment.

### 3.3 Periphyton Biomass and Chlorophyll Content

Periphyton core samples were also analyzed for their dry and ash-free dry weight (AFDW) biomass, chlorophyll *a*, and pheophytin. Exhibit 3-3 summarizes the average data for these parameters by treatment for the study period.

Average periphyton dry weight biomass varied from a low of 286 grams per square meter ( $\text{g}/\text{m}^2$ ) in the dry-down PSTA Test Cell (STC-6) to 1,044  $\text{g}/\text{m}^2$  in the calcium-amended peat Test Cell (STC-4). AFDW biomass varied from a low of 97  $\text{g}/\text{m}^2$  to a high of 340  $\text{g}/\text{m}^2$  for these two extremes.

**EXHIBIT 3-1**

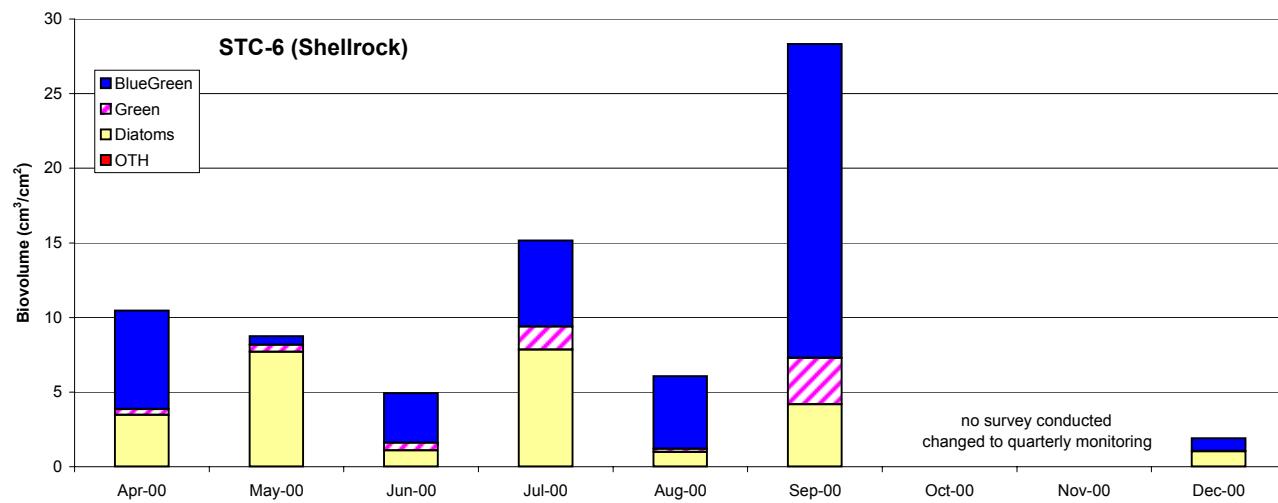
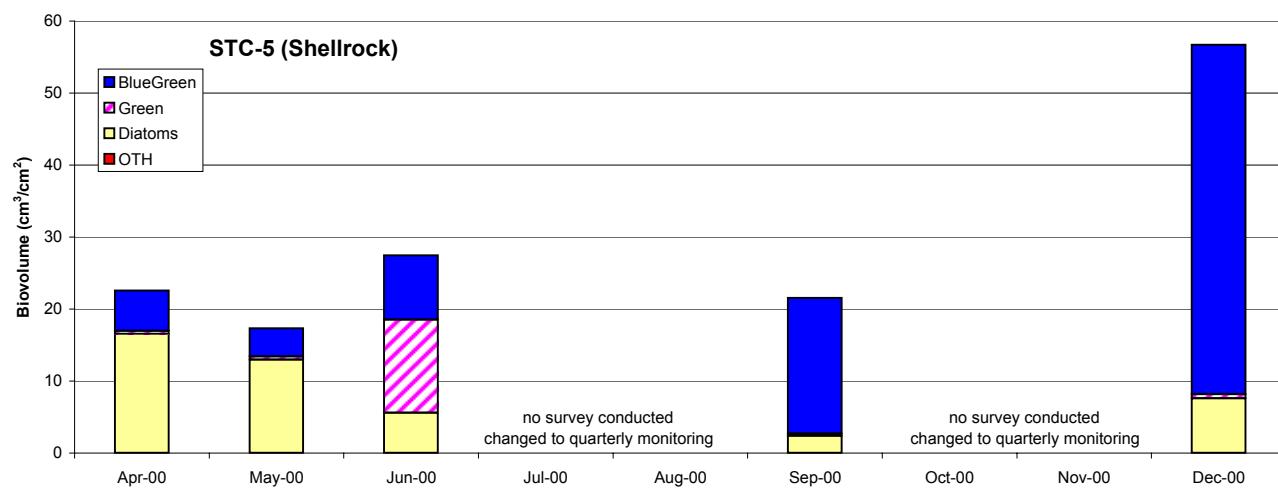
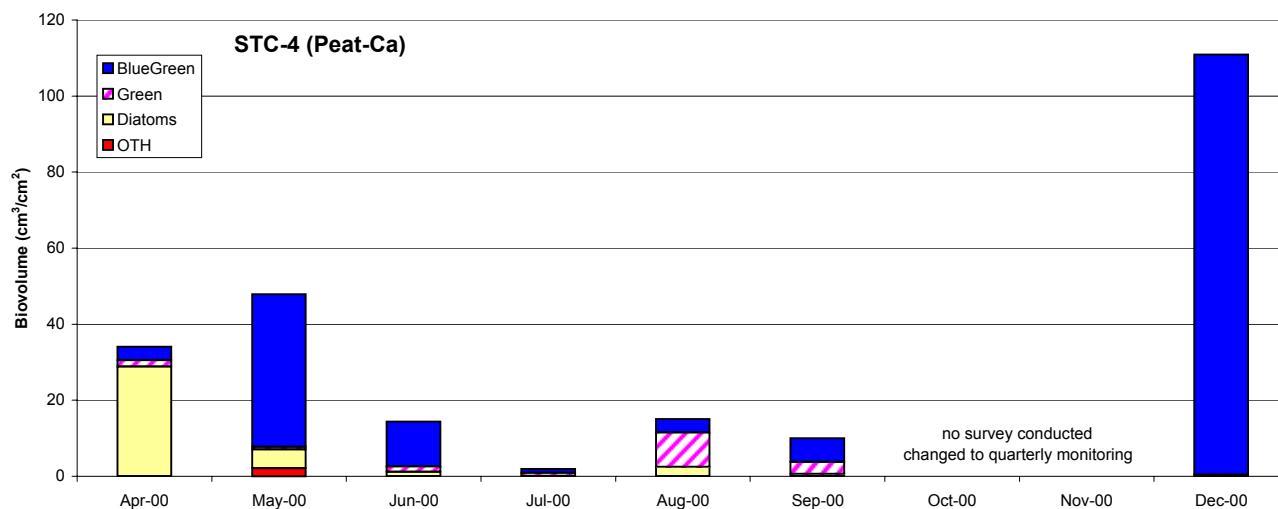
Average Phase 2 PSTA Periphyton Community Algal Populations, April–December 2000

Treatment	Description	Blue-Green Algae		Diatoms		Green Algae		Other Taxa		Total Taxa		Biovolume	Evenness	SWDI
		cells/ m <sup>2</sup> *10 <sup>6</sup>	(# taxa)	(cm <sup>3</sup> /m <sup>2</sup> )										
STC-4	Peat (CaOH)	194,039	11	9,288	8	2,635	5	47	<1	199,012	22	33.47	0.67	2.95
STC-5	Shellrock	259,903	14	8,573	8	1,437	3	0	<1	269,959	26	29.13	0.70	3.24
STC-6	Shellrock (dryout)	232,857	13	23,503	7	3,402	4	0	<1	238,473	23	10.47	0.68	3.04

Notes:

SWDI = Shannon-Weaver Diversity Index

Periphyton taxonomy conducted quarterly for STC-5 beginning in July 2000 and for STC-4 and STC-6 beginning in November 2000.



**EXHIBIT 3-2**  
Monthly Algal Biovolumes in the PSTA Test Cells, April - December 2000

**EXHIBIT 3-3**

Average Phase 2 PSTA Periphyton Community Biomass, Chlorophyll, and Chemistry, April–December 2000

Treatment	Description	Periphyton Biomass (g/m <sup>2</sup> )			Ca (g/m <sup>2</sup> )	Chl_(a) (corr) (mg/m <sup>2</sup> )	Pheo_a (mg/m <sup>2</sup> )	TP (g/m <sup>2</sup> )	TIP (g/m <sup>2</sup> )	TKN <sup>a</sup> (g/m <sup>2</sup> )
		Dry Wt	Ash Wt	AFDW						
STC-4	Peat (CaOH)	1044	704	340	210	200	45.3	0.641	0.279	7.41
STC-5	Shellrock	440	312	128	112	231	34.9	0.247	0.062	4.56
STC-6	Shellrock (dryout)	286	192	97	87	131	19.6	0.300	0.110	3.92

Notes:

<sup>a</sup>TKN analyzed quarterly

Phase 2 = April–December 2000

As noted in the *Phase 1 Summary Report* (CH2M HILL, August 2000), the peat biomass estimates are likely high because of the unavoidable inclusion of some peat sediment in the samples. Chlorophyll and pheophytin values provide an estimate of the amount of photosynthetic matter present in the periphyton samples. Data across treatments are relatively consistent for these parameters. Average corrected chlorophyll *a* ranged from 131 to 231 mg/m<sup>2</sup>. Pheophytin estimates were typically highest in the peat Test Cell, indicating that these periphyton communities have a greater fraction of senescing algae than the other treatments.

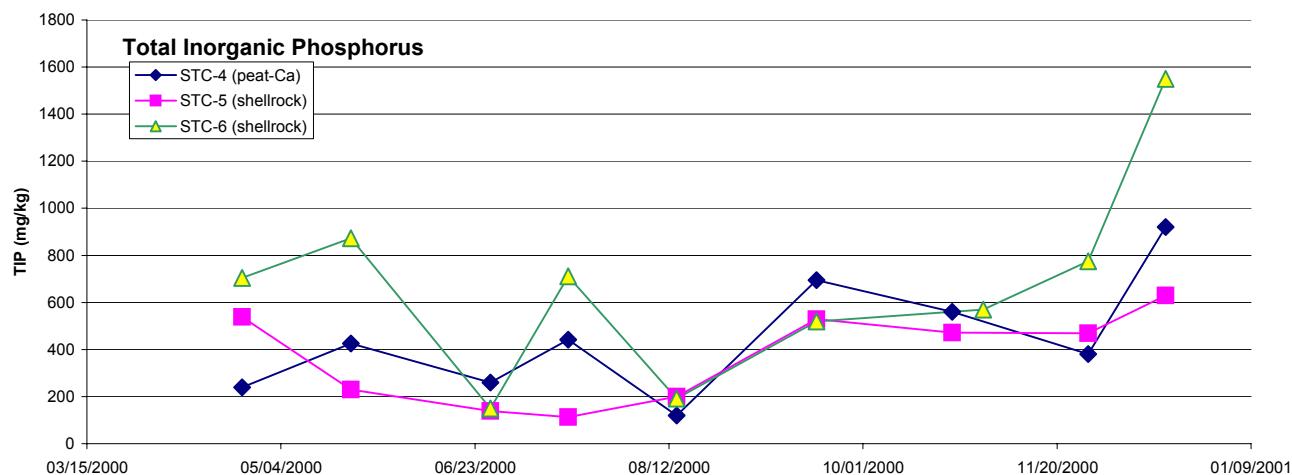
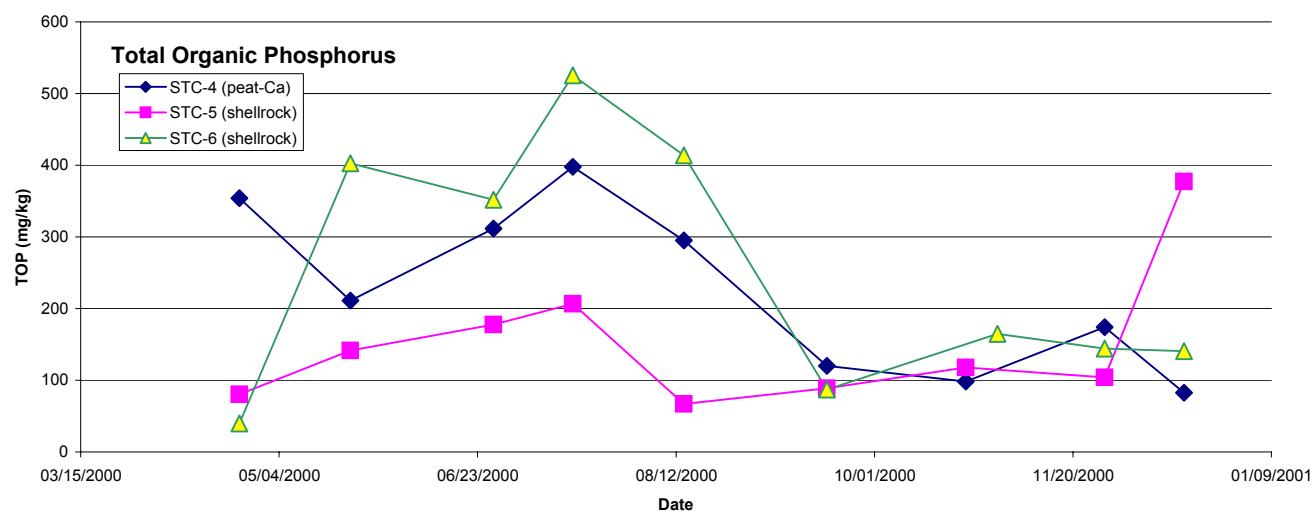
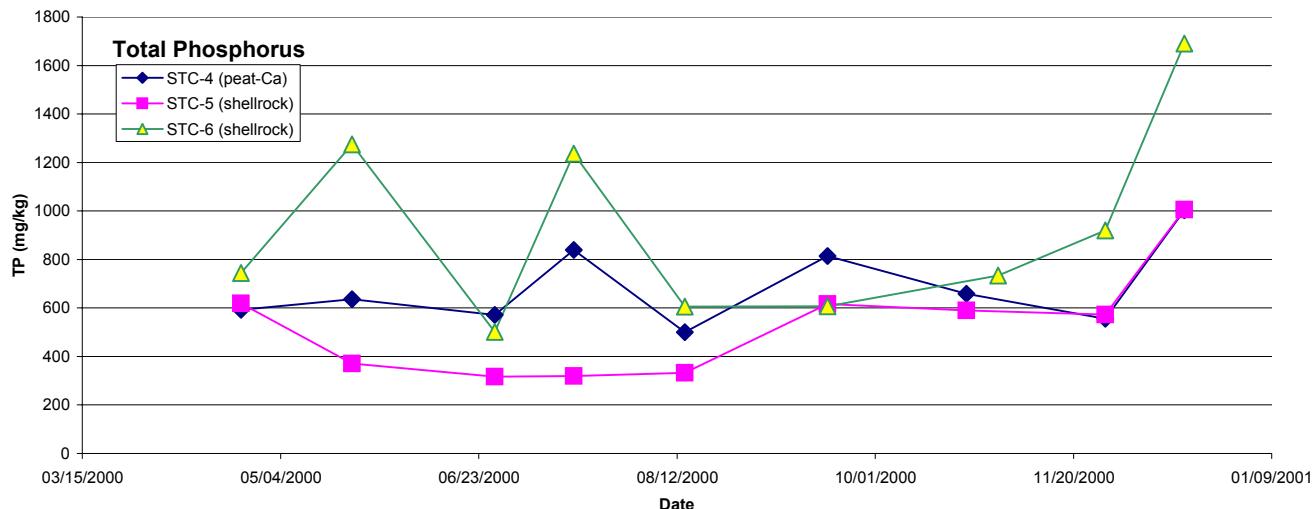
### 3.4 Periphyton Chemical Composition

Exhibit 3-3 also summarizes data for calcium, P, and total Kjeldahl nitrogen (TKN) content of the periphyton for the study period. Average periphyton calcium content ranged from 87 to 210 g/m<sup>2</sup>, with the highest amount of periphyton calcium in the peat treatment (possibly because of inclusion of peat soils in these samples). Average periphyton TKN mass ranged from approximately 3.9 to 7.4 g/m<sup>2</sup>.

Average periphyton TP mass ranged from 247 mg/m<sup>2</sup> in STC-5 to 641 mg/m<sup>2</sup> in STC-4. Monthly periphyton P concentrations are summarized in Exhibit 3-4. Concentrations of TP, TOP, and TIP in the periphyton overlapped for the three PSTA Test Cell treatments during this period. Monthly average TP concentrations varied between approximately 300 and 1,700 mg/kg. Organic and inorganic P fractions were variable in the periphyton during this Phase 2 interim period.

### 3.5 Macrophytes

It is unlikely that larger-scale PSTA systems can remain free of macrophytes without significant intervention. Also, sparse macrophyte communities are likely to be helpful for maintaining higher periphyton populations by providing attachment sites and anchoring against wind-induced periphyton movement. For these reasons, the PSTA Test Cell treatments were intentionally planted with macrophytes, specifically spikerush (*Eleocharis cellulosa*) and bladder-wort (*Utricularia* sp.). One goal of the project is the documentation of the growth rate and density of these macrophytes, as well as volunteer plant species, and to attempt to identify a macrophyte density and control strategy that optimizes periphyton development and overall system P removal performance.



**EXHIBIT 3-4**  
Monthly Periphyton TP, TIP, and TOP Concentrations in the PSTA Test Cells, April - December 2000

Exhibit 3-5 summarizes the macrophyte results for the interim period. Detailed monthly data are provided in Appendices B-8 and B-13. Cover numbers are visual estimates for comparison purposes and do not provide an exact assessment of total leaf cover. Biomass values are from plants collected in periphyton core samples. Principal volunteer macrophytic plant species in the PSTA Test Cells were cattails (*Typha latifolia*), hydrilla (*Hydrilla verticillata*), and the macro-algae chara (*Chara* sp.).

**EXHIBIT 3-5**  
PSTA Macrophyte Cover and Biomass, April–December 2000

Treatment	Description	Emergent Macrophytes	Submerged Aquatic Plants	Total Macrophyte % Cover	Macrophyte Biomass (g/m <sup>2</sup> )
STC-4	Peat (CaOH)	17%	71%	88%	319
STC-5	Shellrock	41%	84%	125%	402
STC-6	Shellrock (dryout)	40%	28%	68%	135

Notes:

Macrophyte percent cover is visually estimated using a semi-quantitative method.

Macrophyte biomass is estimated from periphyton core samples.

Stem counts are for live stems only.

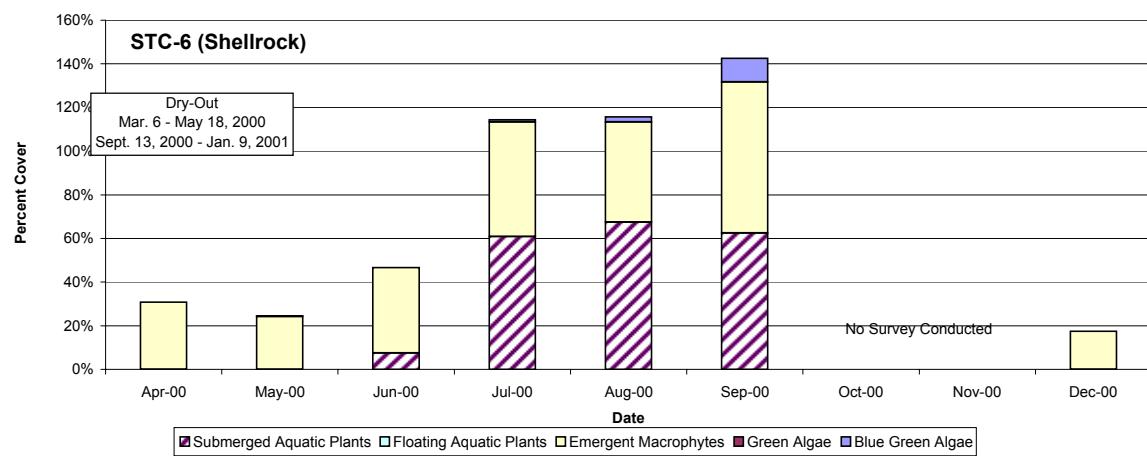
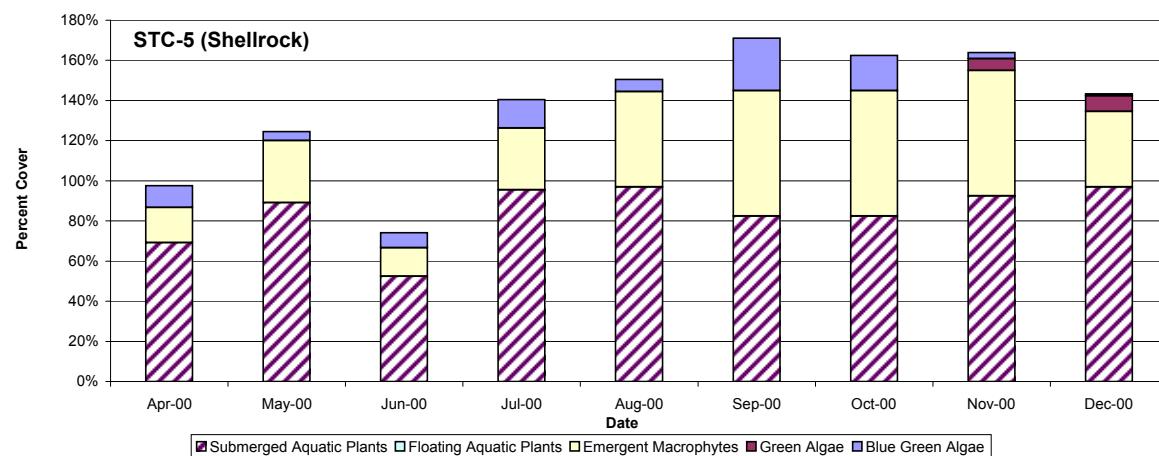
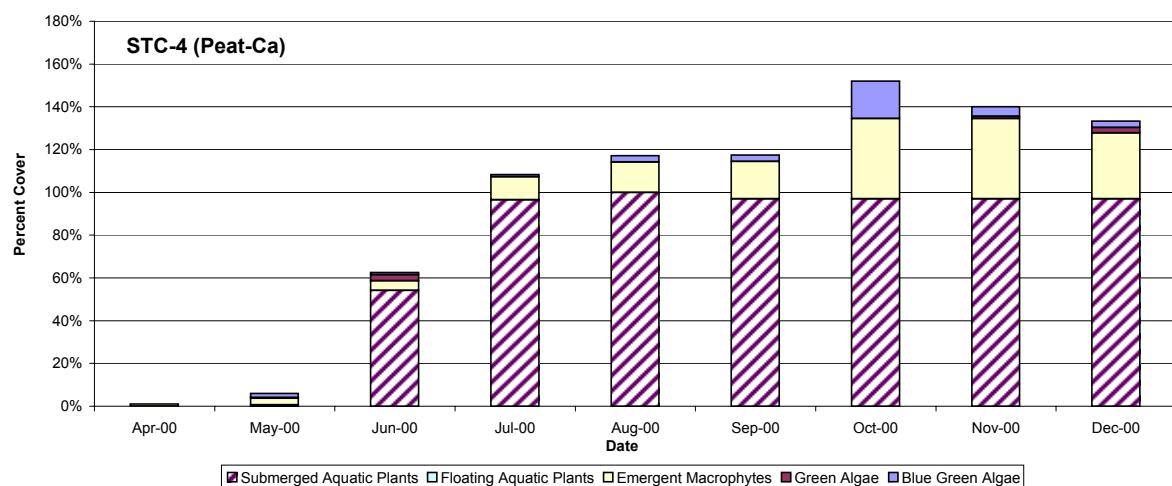
Macrophyte populations were dominated by submerged aquatic vegetation (SAV) in STC-4 and STC-5 with average cover ranging from 71 to 84 percent, respectively, in these two cells. Treatment STC-6 had an average SAV cover of 28 percent during this period. SAV cover in this cell was reduced to zero during the December 2000 survey after nearly 3 months of dryout. Emergent macrophyte cover in the two shellrock cells averaged approximately 40 percent during the Phase 2 interim period, while emergent cover in the peat cell average 17 percent. All of the emergent vegetation was removed from this cell at the beginning of Phase 2, except for a sparse planting of spikerush.

The time series trends in macrophyte cover for the three PSTA Test Cell Phase 2 treatments are illustrated in Exhibit 3-6. Live macrophyte cover was clearly reduced in STC-6 during the two dry-out periods. Overall average Phase 2 macrophyte cover and biomass was greatest in STC-5 with 125 percent and 402 g/m<sup>2</sup>. These higher average values were likely the result of the stable water level conditions in this Test Cell from Phase 1 through Phase 2.

### 3.6 Community Metabolism/Productivity

PSTA Test Cell community metabolism data for the Phase 2 interim period are summarized in Exhibit 3-7. Detailed monthly average community metabolism data are provided in Appendix B-15. These metabolism estimates are for the water column only, and do not include primary productivity and respiration of the emergent plant species.

Average gross primary productivity (GPP) ranged from 2.8 g O<sub>2</sub>/m<sup>2</sup>/d in STC-4 to 4.7 g O<sub>2</sub>/m<sup>2</sup>/d in STC-6. Community respiration (CR) rates were similar to GPP, resulting in average GPP/CR ratios between 0.95 and 1.01. These metabolism estimates indicate that there was a slightly negative net primary productivity (NPP) recorded in treatments STC-4 and STC-5 for this Phase 2 interim period. The dry-out treatment (STC-6) had a slight positive NPP during this same period. CR and the apparent low level of NPP include the effects of litterfall and subsequent decomposition of emergent plants as well as sediment oxygen



**EXHIBIT 3-6**  
Monthly Macrophyte Percent Cover Estimates in the PSTA Test Cells, April - December 2000

**EXHIBIT 3-7**

PSTA Community Metabolism Data, April–December 2000

Treatment	Description	GPP(day) g/m <sup>2</sup> /d	CR(24hr) g/m <sup>2</sup> /d	P/R Ratio	NPP(24hr) g/m <sup>2</sup> /d	PAR(24hr) mol/m <sup>2</sup> /d	Efficiency %
STC-4	Peat (CaOH)	2.812	2.961	0.95	-0.149	28.8	1.7
STC-5	Shellrock	3.305	3.401	0.97	-0.096	28.4	2.0
STC-6	Shellrock (dryout)	4.722	4.654	1.01	0.068	32.0	2.9

## Notes:

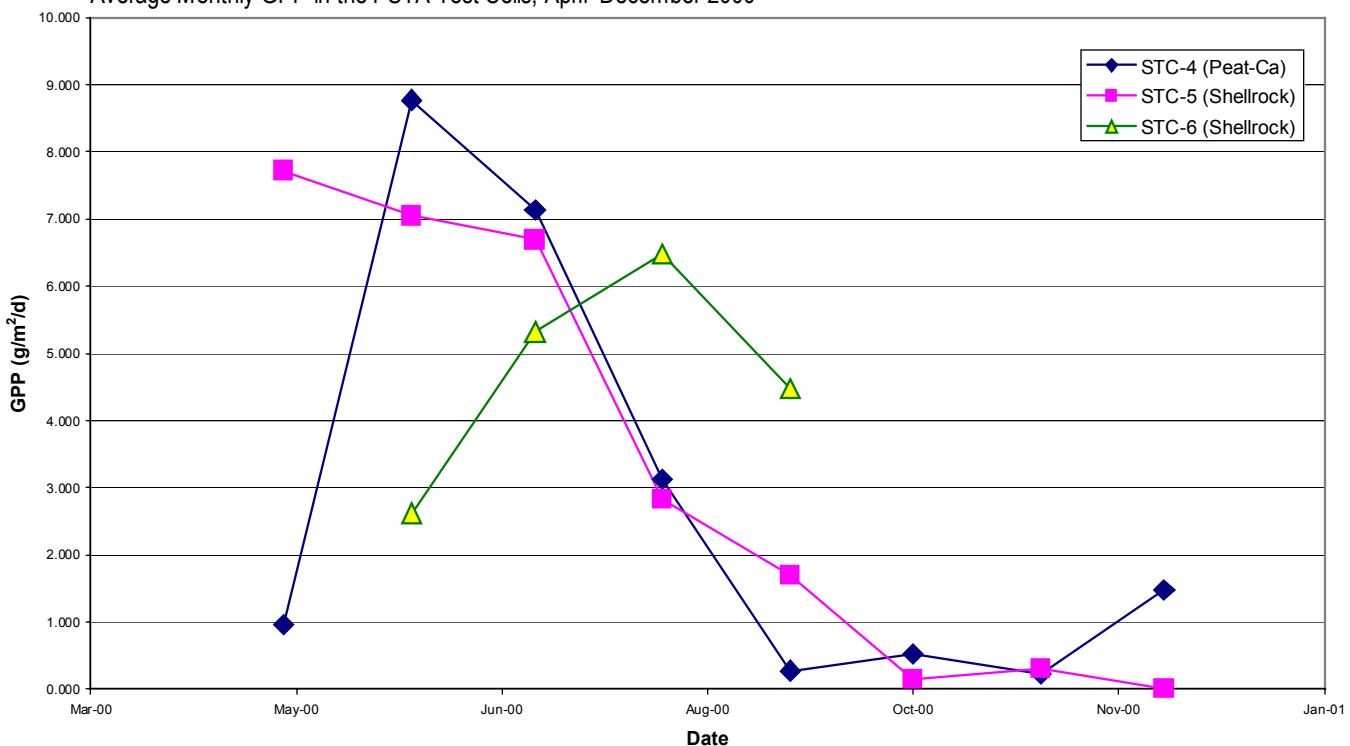
Photosynthetic efficiency is calculated with above-water PAR and the assumption that 1 g O<sub>2</sub>/m<sup>2</sup> equals 10 kcal and 1 Einstein (E) of photons equals 52.27 kcal.

demand from high organic content of peat soils in STC-4. Percent cover estimates indicate that there were increases in aquatic plant (algae and macrophytes) biomass in treatments STC-4 (peat) and STC-5 (shellrock).

GPP trends are illustrated in Exhibit 3-8. Metabolism was initially high during the summer months and dropped off substantially by early fall. The GPP for the dry-out PSTA Test Cell lagged behind the other two cells, with a seasonal maximum in August 2000 and a later decline in the fall. Lower GPP rates generally coincide with higher emergent macrophyte cover (see Exhibit 3-6), illustrating the shading effect of the emergent plant species on the periphyton and SAV.

**EXHIBIT 3-8**

Average Monthly GPP in the PSTA Test Cells, April–December 2000



## SECTION 4

# PSTA Forecast Model

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## 4.1 Introduction

Since the timeframe available for development of the PSTA technology is limited and compliance schedules are dictated by law, tools are being developed to forecast performance and aid with design of full-scale PSTA systems. A PSTA forecast model is being developed to allow quantitative predictions of future performance.

The Dynamic Model for Stormwater Treatment Areas (DMSTA) being developed by the Department of Interior consultants provides a preliminary tool for comparison of various ecosystem-based treatment technologies. The DMSTA model is applicable to PSTA and provides a relatively accurate estimate of P removal performance. However, the DMSTA model does not include key ecological components of importance to specific ecosystem-based technologies. For example, the DMSTA model provides no indication of the amount of organic matter that accumulates in green treatment systems and does not include the seasonal influence of solar radiation, one of the principal external energy inputs driving processes in "green technologies". Understanding of the carbon-based storages in addition to P is important in foreseeing management issues that will arise as green technologies mature.

This section provides a description of the draft PSTA Forecast Model under development for the PSTA Research and Development Project. It provides an overview of the model structure, the basis for calibration of the model, and a preliminary summary of results for various alternative PSTA configurations. This section also provides guidance for using the PSTA Forecast Model. This is a working document and will be updated as the model is refined.

### 4.1.1 Background

The PSTA concept is being tested within a relatively short schedule as dictated by law. Full-scale, long-term performance results will not be available within the timeframe of regulatory compliance. Furthermore, operational and management costs of a full-scale PSTA system will not be available based on extended operational experience. Thus, modeling of the key PSTA processes and performance is the only available method that allows estimation of the area needed to meet TP goals. This type of informed estimate is essential for PSTA conceptual design and assessment of construction and operating costs.

Methods for forecasting PSTA operation and performance range in complexity from single- to multiple-parameter models. One- and two-parameter model calibration results ( $k_1$  and  $k-C^*$  models) were presented in the *PSTA Research and Demonstration Project Phase 1 Summary Report* (CH2M HILL, August 2000). In addition, a "Level 2" PSTA Model has been developed using a Microsoft® Access platform and has been partially calibrated to provide a more complete and mechanistic method for performance forecasting. This model is described in the *PSTA Research and Demonstration Project 5<sup>th</sup> Quarterly Report* (CH2M HILL, January 2000) and incorporates more complexity than can be realistically supported at this time by experimental data.

The PSTA Forecast Model uses Microsoft® Excel as an operating platform rather than Access. This change was made to widen the audience who could use the PSTA Forecast Model for assessing expected performance. The PSTA Forecast Model includes the following modifications from the “Level 2” Access model described in earlier project reports:

- Inclusion of external forcing functions to provide the best understanding of processes that control the natural periphyton-based treatment system, including sunlight (seasonally variable), rainfall (both direct and through stormwater inputs), and atmospheric inputs/outputs (ET, diffusion of oxygen and carbon dioxide, physical mixing, resuspension, plant and animal migration, and atmospheric pollutant loads).
- Simplification of the Level 2 model to include only predictions of TP data.
- Addition of a more dynamic water balance with stage-storage relationships.
- Consideration of human management influences (construction of landform, water pumping and depth control, biomass removal, maintenance, and related actions).

#### **4.1.2 Data Sources**

Three research platforms will eventually provide calibration and verification data for the PSTA Forecast Model. These mesocosm systems include:

- 24 portable PSTA mesocosms (Porta-PSTAs) ranging in size from 6 m<sup>2</sup> to 18 m<sup>2</sup>
- 3 PSTA Test Cells (2,040 m<sup>2</sup> each)
- 4 Field-Scale PSTA (20,000 m<sup>2</sup> each)

Only the Porta-PSTA and Test Cell mesocosms currently have usable calibration/validation data. The Porta-PSTA mesocosms were operated for 18 months. Numerous treatments were investigated, including multiple replicated configurations. The PSTA Test Cells were operated for 24 months, with three basic configurations tested. The Field-Scale PSTAs are expected to commence operation in the summer of 2001. Data from these systems will provide validation of models calibrated from the other two PSTA research scales.

## **4.2 Model Construction**

Exhibit 4-1 presents a diagram of the PSTA Forecast Model along with the major state variable equations and definitions of variables. The model consists of four principal component storages:

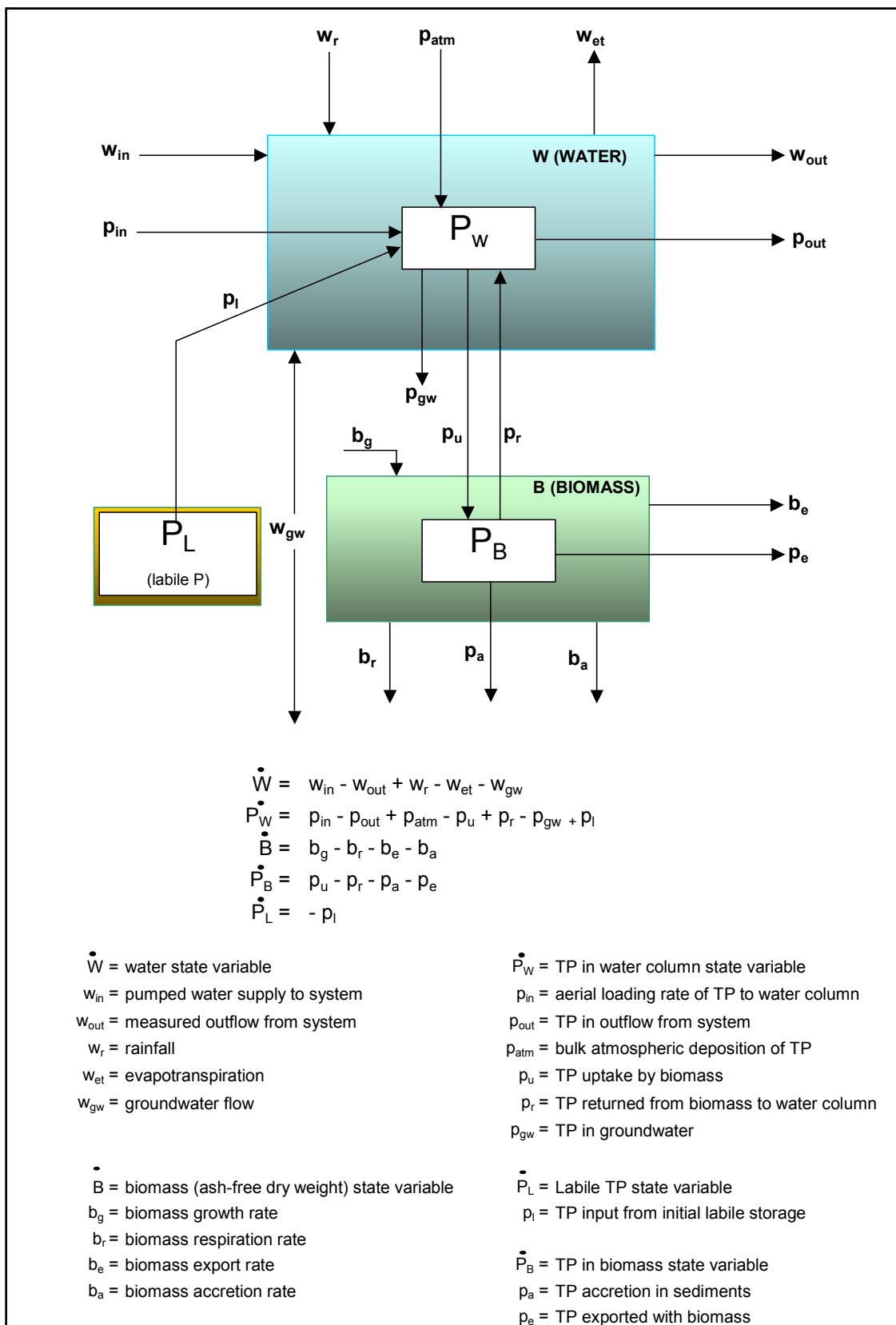
- water (W)
- TP in the water column (P<sub>W</sub>)
- periphyton biomass (B)
- TP in the biomass (P<sub>B</sub>)

In addition, an initial storage of labile P (P<sub>L</sub>) is included to allow simulation of startup releases of TP from pre-existing soils and decaying vegetation.

Each of these state variables is described in detail in the following paragraphs. Exhibit 4-2 summarizes the equations used to calculate each pathway or storage component and identifies the data sources that are available for model calibration.

**EXHIBIT 4-1**

PSTA Forecast Model Diagram



**EXHIBIT 4-2**
**PSTA Forecast Model Variables and Equations**

<b>Variable</b>	<b>Calculated as</b>	<b>1° Units</b>	<b>Description</b>
A	= Wetted area	m <sup>2</sup>	PSTA footprint area
W <sub>W</sub>	= W <sub>initial</sub> + W <sub>dt</sub>	m	Water
• W <sub>W</sub>	= w <sub>in</sub> - w <sub>out</sub> + w <sub>r</sub> - w <sub>et</sub> - w <sub>gw</sub>	m/d	water rate of change
w <sub>in</sub>	= Q <sub>IN</sub>	m/d	pumped inflow
w <sub>out</sub>	= applicable weir equation	m/d	water out
w <sub>r</sub>	= Precip * A	m/d	Rainfall
w <sub>et</sub>	= ET * A	m/d	Evapotranspiration
w <sub>gw</sub>	= seepage rate	m/d	groundwater exchange
P <sub>w</sub>	= (P <sub>w_initial</sub> + P <sub>w_dt</sub> )W	gTP/m <sup>3</sup>	water column TP
• P <sub>w</sub>	= p <sub>in</sub> - p <sub>out</sub> + p <sub>atm</sub> - p <sub>u</sub> + p <sub>r</sub> - p <sub>gw</sub>	gTP/m <sup>2</sup> /d	water column TP rate of change
p <sub>in</sub>	= (C <sub>IN</sub> * Q <sub>IN</sub> )/A	gTP/m <sup>2</sup> /d	TP in pumped inflow
p <sub>out</sub>	= (P <sub>w</sub> * Q <sub>OUT</sub> )/A	gTP/m <sup>2</sup> /d	TP in surface outflow
p <sub>atm</sub>	= (C <sub>ATM</sub> * Precip)/A	gTP/m <sup>2</sup> /d	bulk atmospheric deposition
p <sub>u</sub>	= k <sub>u</sub> *P <sub>w</sub> *B	gTP/m <sup>2</sup> /d	TP uptake by biomass
p <sub>r</sub>	= b <sub>r</sub> *P <sub>B</sub> /B	gTP/m <sup>2</sup> /d	TP returned to water column from biomass/sediments
p <sub>gw</sub>	= P <sub>w</sub> *w <sub>gw</sub>	gTP/m <sup>2</sup> /d	TP in groundwater exchange
B	= B <sub>initial</sub> + B <sub>dt</sub>	g AFDW/m <sup>2</sup>	Biomass (ash-free dry weight)
• B	= b <sub>g</sub> - b <sub>d</sub> - b <sub>e</sub> - b <sub>a</sub>	g AFDW/m <sup>2</sup> /d	Biomass rate of change
b <sub>g</sub>	= k <sub>g</sub> * (l/(k <sub>si</sub> + l)) * (P <sub>w</sub> /(k <sub>sp</sub> + P <sub>w</sub> )) * B	g AFDW/m <sup>2</sup> /d	biomass growth
b <sub>r</sub>	= k <sub>r</sub> * B <sup>2</sup>	g AFDW/m <sup>2</sup> /d	biomass respiration rate
b <sub>e</sub>	= k <sub>e</sub> B + HB	g AFDW/m <sup>2</sup> /d	biomass export
b <sub>a</sub>	= k <sub>a</sub> * B	g AFDW/m <sup>2</sup> /d	biomass accretion
H	= user defined	d <sup>-1</sup>	harvesting coefficient
P <sub>B</sub>	= P <sub>B-initial</sub> + P <sub>B_dt</sub>	gTP/m <sup>2</sup>	TP in biomass
• P <sub>B</sub>	= p <sub>u</sub> - p <sub>r</sub> - p <sub>a</sub> - p <sub>e</sub>	gTP/m <sup>2</sup> /d	TP in biomass rate of change
p <sub>u</sub>	= k <sub>u</sub> *P <sub>w</sub> *B	gTP/m <sup>2</sup> /d	TP uptake by biomass growth and luxury uptake
p <sub>r</sub>	= b <sub>r</sub> *P <sub>B</sub> /B	gTP/m <sup>2</sup> /d	TP returned to water column from biomass/sediments
p <sub>a</sub>	= b <sub>a</sub> *P <sub>B</sub> /B	gTP/m <sup>2</sup> /d	TP in accreted biomass
p <sub>e</sub>	= b <sub>e</sub> *P <sub>B</sub> /B	gTP/m <sup>2</sup> /d	TP exported in biomass
P <sub>L</sub>	= PL <sub>initial</sub> + P <sub>L_dt</sub>	gTP/m <sup>2</sup>	Initial labile TP
• P <sub>L</sub>	= - p <sub>l</sub>	gTP/m <sup>2</sup> /d	Labile TP rate of change
p <sub>l</sub>	= k <sub>l</sub> P <sub>L</sub>	gTP/m <sup>2</sup> /d	TP input from initial labile storage

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**EXHIBIT 4-2**

## PSTA Forecast Model Variables and Equations

Variable	Calculated as	1° Units	Description
$k_g$	=	d <sup>-1</sup>	biomass growth rate
$k_{si}$	=	mol/m <sup>2</sup> /d	half saturation constant for PAR
$k_{sp}$	=	gTP/m <sup>3</sup>	half saturation constant for water column TP
$k_r$	=	m <sup>2</sup> /gAFDW/d	biomass respiration rate constant
$k_e$	=	d <sup>-1</sup>	biomass export rate constant
$k_a$	=	d <sup>-1</sup>	accretion rate constant
$k_u$	=	m <sup>3</sup> /gAFDW/d	luxury uptake constant
$k_l$	=	d <sup>-1</sup>	P release from labile storage rate constant
$k_{net}$	= $(p_a - p_l)/P_w * 365$	m/y	TP net settling rate
$Q_{in}$		m <sup>3</sup> /d	inflow
$Q_{out}$		m <sup>3</sup> /d	outflow
Rain		m/d	rainfall
ET		m/d	evapotranspiration
Weir Ht.		ft	weir height
$C_{in\,TP}$		mgTP/L	TP inflow concentration
$C_{atm\,TP}$		mgTP/L	TP in rainfall
I (PAR)		mol/m <sup>2</sup> /d	photosynthetically active radiation

#### 4.2.1 Water Column (W)

The water column component is represented by a general water balance equation. The water “state” at any time is the difference between the sum of the flow inputs (pumped inflow and precipitation) and outputs (flow over the weir, ET, and groundwater exchange).

For model calibration, the pumped inflow and outflow over the weir were measured in the field. Precipitation data were provided by the District. District ET data are utilized for estimates of this water loss at the PSTA research and demonstration site. No groundwater interactions are expected for water budgets for the Porta-PSTA mesocosm studies and for the PSTA Test Cells because all of these mesocosm systems are lined.

For the Field-Scale PSTAs, groundwater flow will be estimated via a flownet analysis based on differential heads between the upgradient monitor wells, cell stage, and downstream monitor wells. There is no groundwater exchange at either the Porta-PSTAs or Test Cells.

The PSTA Forecast Model utilizes a single well-mixed tank hydraulic framework. This is based on the single-cell configuration of all of the PSTA research test units. Actual tracer data from the PSTA mesocosms indicated that their tracer residence time distributions could be best described as between 1.4 and 3.1 tanks-in-series (TIS), with all of the shellrock mesocosms in the range of 1.4 to 1.8 TIS. A 1.8 TIS model was constructed and tested. It was found that this model framework did not provide a better fit to the actual operational data than the single well-mixed tank

model. For this reason, the TIS model was not used as the final framework for the PSTA Forecast Model.

Water outflow is based on the weir design. The model provides either a horizontal or a V-notch weir. The V-notch weir expression was used to calibrate the model with data from the PSTA Test Cells. The horizontal weir with variable width was used for simulation of larger-scale PSTA systems.

#### **4.2.2 Water Column TP ( $P_w$ )**

TP in the water column is described as the concentration resulting from the net effects of the inflow and outflow concentrations, bulk atmospheric deposition, uptake by the biomass, losses to groundwater, and a return from sediments and biomass.

For calibration, inflow and outflow TP concentrations were directly measured as part of routine monitoring. Previous District measurements of bulk atmospheric deposition were used to estimate this input of P. Uptake of TP by biomass was derived from dry weight measurements of TP from algae and macrophyte samples. The return from sediments and biomass was estimated during the calibration process.

#### **4.2.3 Biomass (B)**

The biomass component consists of the AFDW (total organic content) of the benthic periphyton mat, epiphytic algae, tychoplankton, and detritus. Macrophytic plants are not explicitly included in the model. The biomass state variable depends upon periphyton growth and respiration rates, algal export from the system measured as total suspended solids (TSS), and accretion of algal solids in the detrital layer.

Periphyton growth is calculated as a function of incident solar radiation using a Monod expression,  $P_w$  concentration with a Monod expression, and periphyton biomass. During calibration, it was found that  $P_w$  has no observable effect on the productivity of these periphyton communities. Therefore, the half saturation constant for  $P_w$  was set to zero for model calibration. This observation is likely a result of the very low TP concentrations encountered in this study. The  $k_{sp}$  value can be reset if data become available for higher TP inflow concentrations.

Periphyton respiration is modeled as a quadratic drain (proportional to the periphyton biomass squared). A linear (first order) expression was initially used but was found to result in model instability. The quadratic expression has been found to be an effective model to describe growth of a variety of ecological plant communities.

Periphyton export and accretion are first order expressions based on the total periphyton biomass.

#### **4.2.4 Biomass TP ( $P_B$ )**

TP in the biomass depends on uptake from the water column, internal recycling, and losses to respiration (back to the water column), accretion of biomass, and export of biomass in the outflow water. Measured effluent concentrations for TSS were used to derive the export rates.

Periphyton TP uptake is proportional to the product of the water TP ( $P_w$ ) and the amount of periphyton biomass (B). TP lost as a result of periphyton respiration is proportional to the product of the periphyton decay rate multiplied by the concentration of TP in B. The TP accretion rate and export rate are both based on the same relationship.

#### 4.2.5 Labile TP Storage ( $P_L$ )

Startup data from most of the PSTA mesocosms indicated that there were initial storages of labile TP in the antecedent soils that entered the water column upon flooding. These initial storages are modeled as a tank that is initially full of TP with a single outlet to the water column. This addition to the model helps duplicate the startup behavior observed, not only at the beginning of the project, but also at the mid-point of the project when the sediments in the peat-based PSTA Test Cell were highly disturbed.

#### 4.2.6 PSTA Dry-out

PSTA Test Cell 3 was operated in a periodic dry-out mode to determine the effects of periphyton dry-out on a large scale. The PSTA Forecast Model was found to be unstable as water levels declined to near dry-out conditions. For this reason, it was decided to incorporate some logic switches to capture the main effects of dry-out. Two types of switches are included in the model. The first reduces the rates of biomass growth and decay by 90 percent when water depth is less than 5 cm. Organic matter decomposition is typically much lower in the air in aquatic environments. The second switch stops calculating  $P_w$  and B when water levels are less than 5 cm. This switch is necessary to prevent mathematical integration problems associated with zero values.

### 4.3 Coefficient Estimation

As shown in Exhibit 4-2, the following adjustable coefficients are required by the model:

- $k_g$  ( $d^{-1}$ ) periphyton biomass growth rate constant
- $k_{si}$  ( $E/m^2/d$ ) half saturation constant for solar radiation (PAR)
- $k_{sp}$  ( $gTP/m^3$ ) half saturation constant for periphyton uptake of water-column TP
- $k_r$  ( $m^2/gAFDW/d$ ) periphyton biomass respiration rate constant
- $k_e$  ( $d^{-1}$ ) periphyton biomass export rate constant
- $k_a$  ( $d^{-1}$ ) periphyton biomass accretion rate constant
- $k_u$  ( $m^3/gAFDW/d$ ) periphyton TP uptake rate constant
- $k_l$  ( $d^{-1}$ ) TP release rate constant from labile storage

PSTA mesocosm data were analyzed to develop initial estimates for some of these parameters. Only the shellrock treatment data were reviewed for this range-finding effort.

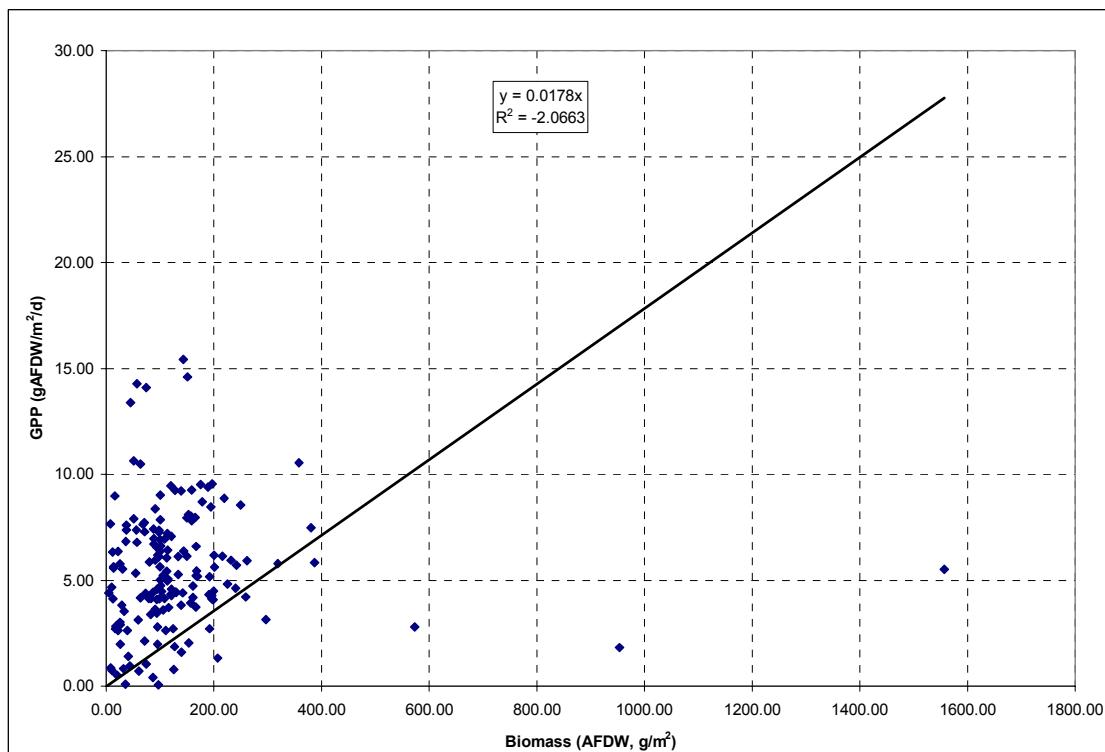
#### 4.3.1 Biomass Growth Rate ( $k_g$ )

Biomass growth is partially dependent on the amount of biomass already present in the system at any given time. Measures of photosynthetic activity, such as GPP, provide insight into the rate at which the biomass community is growing. GPP estimates in units of dissolved oxygen change ( $g O_2/m^2/d$ ) have been converted to AFDW by multiplying by a factor of 2x.

Exhibit 4-3 shows the observed relationship between monthly average values for GPP and total biomass in all of the shellrock treatments. Although no clear correlation exists between these two parameters, this correlation is affected because many factors other than biomass and GPP vary during the operational period. However, for model calibration, the slope of the regression line provides an initial value for  $k_g$  of 0.0178 d<sup>-1</sup>.

#### EXHIBIT 4-3

##### Observed Relationship Between Periphyton Biomass and GPP in PSTA Shellrock Mesocosms



#### 4.3.2 Half Saturation Constants for PAR and TP

The rate of biomass growth is also partially limited by solar radiation (i.e., photosynthesis) and the availability of nutrients. The PSTA Forecast Model assumes that both light and nutrient availability follow the Michaelis-Menten model, which implies that reaction rates increase with substrate concentration until a maximum reaction rate is approached. At that point, the addition of substrate no longer affects the reaction rate. The half saturation constant describes the substrate concentration required for the reaction to proceed at half its maximum rate.

Exhibit 4-4 shows the average monthly relationships between GPP and PAR in the shellrock treatments. The reciprocals of GPP and PAR have been plotted to linearize the Michaelis-Menten relationship. Data sets that follow the Michaelis-Menten equation will plot as a line with a positive slope and a negative x-intercept. The value of the half saturation constant is given as -1/x-intercept. The average value of the half saturation constant for PAR ( $k_{si}$ ) is 84.5 E/m<sup>2</sup>/d. This value was used as a starting point for model calibration.

**EXHIBIT 4-4**

## Observed Relationship Between Inverse of PAR and GPP in PSTA Shellrock Mesocosms

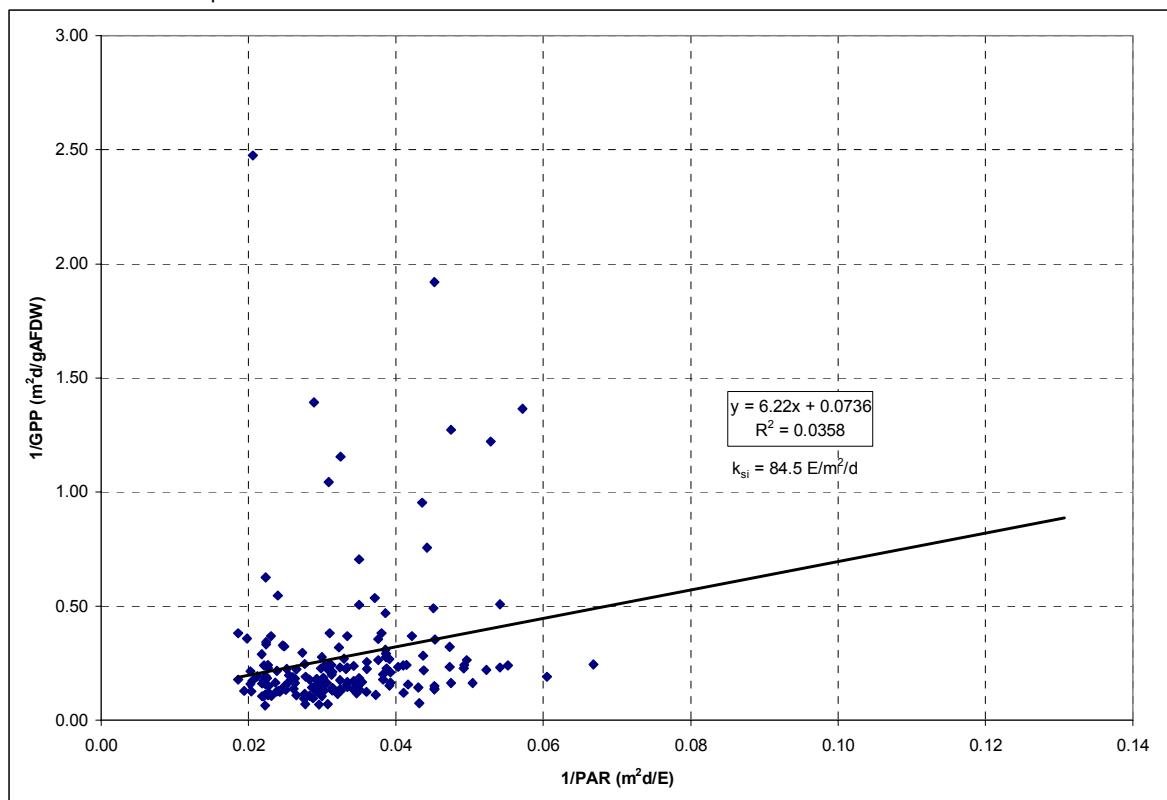
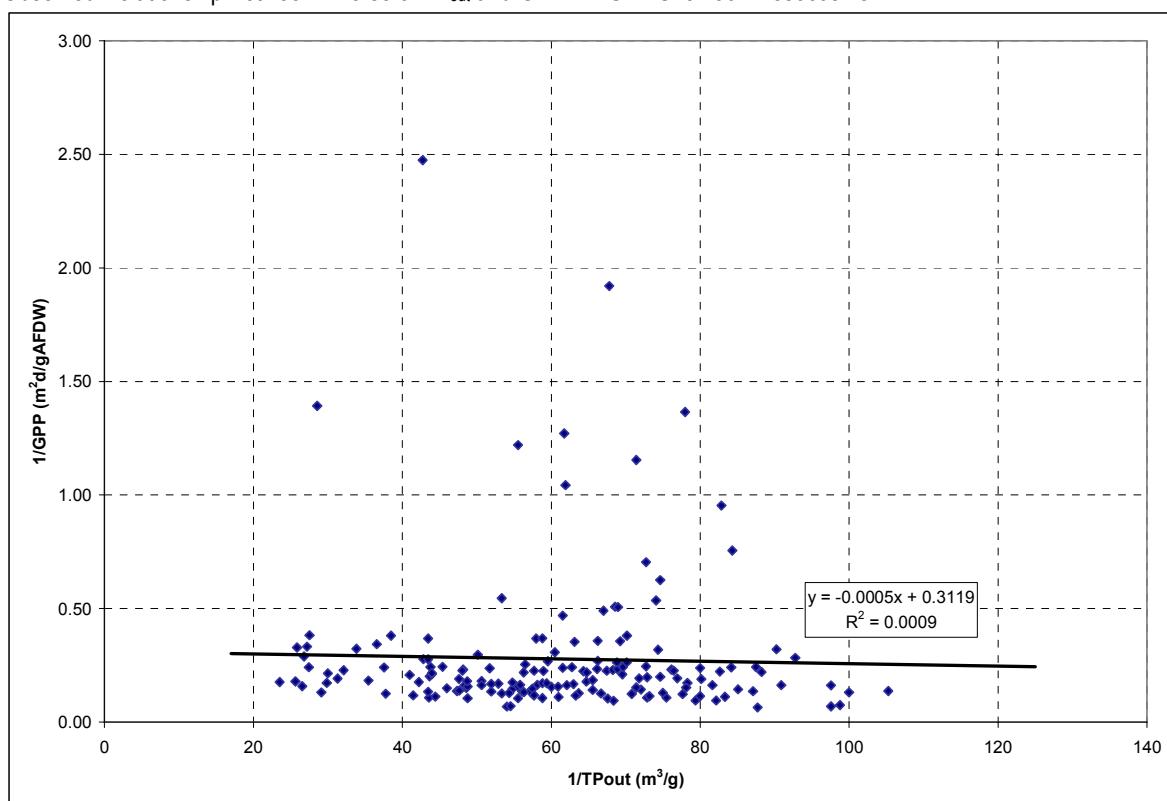


Exhibit 4-5 shows a similar plot for the reciprocals of GPP and water column TP concentration in shellrock treatments. No clear Michaelis-Menten relationship is apparent for these data. The range of observed water column TP concentrations has probably not been wide enough to show the assumed limiting effect of TP on biomass growth. A value of 0 mg/L was used for the half saturation constant for TP ( $k_{sp}$ ).

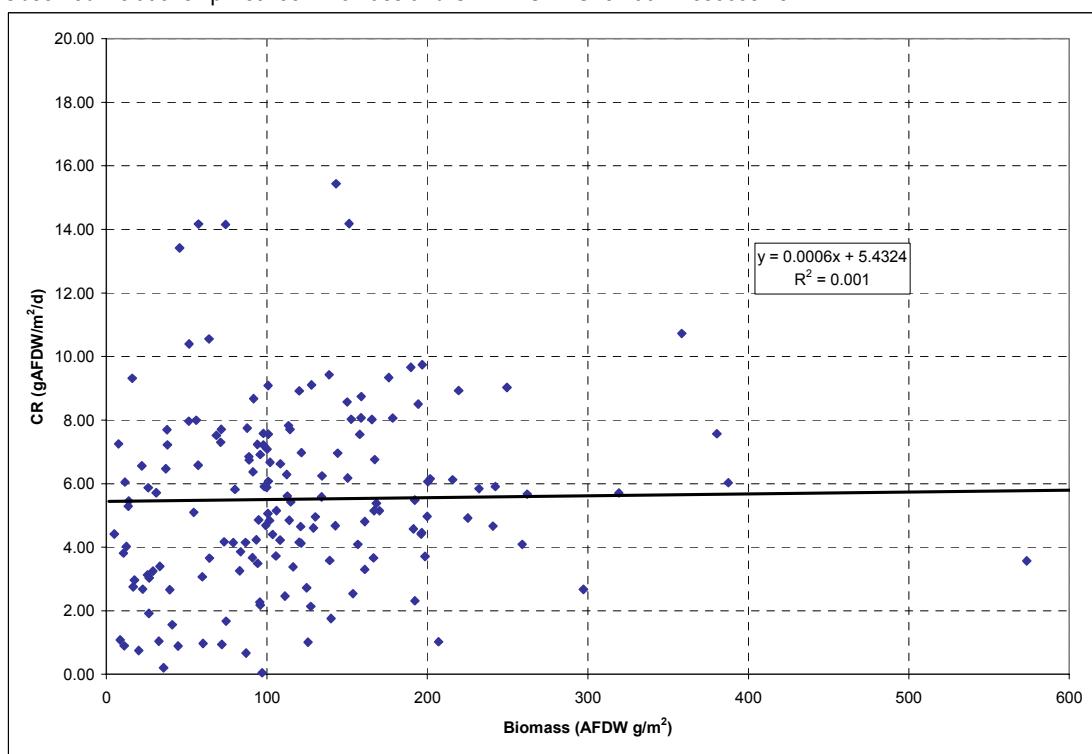
### 4.3.3 Biomass Respiration Rate ( $k_r$ )

Exhibit 4-6 shows the observed relationship between biomass and CR in the PSTA shellrock-based treatments. There was no apparent correlation observed between these two parameters. However, because the model was found to be very sensitive to  $k_r$  and the CR rate, it was decided to use a quadratic drain to model this process.

Exhibit 4-7 shows the relationship between observed values for CR and the square of biomass in shellrock treatments. Community respiration measurements are used to approximate the decay rate of biomass in the mesocosms. The slope of the regression line ( $0.0001 \text{ d}^{-1}$ ) was used as the initial model value for  $k_r$ .

**EXHIBIT 4-5**Observed Relationship Between Inverse of TP<sub>out</sub> and GPP in PSTA Shellrock Mesocosms**EXHIBIT 4-6**

Observed Relationship Between Biomass and CR in PSTA Shellrock Mesocosms



**EXHIBIT 4-7**

## Observed Relationship Between Square of Biomass and CR in PSTA Shellrock Mesocosms

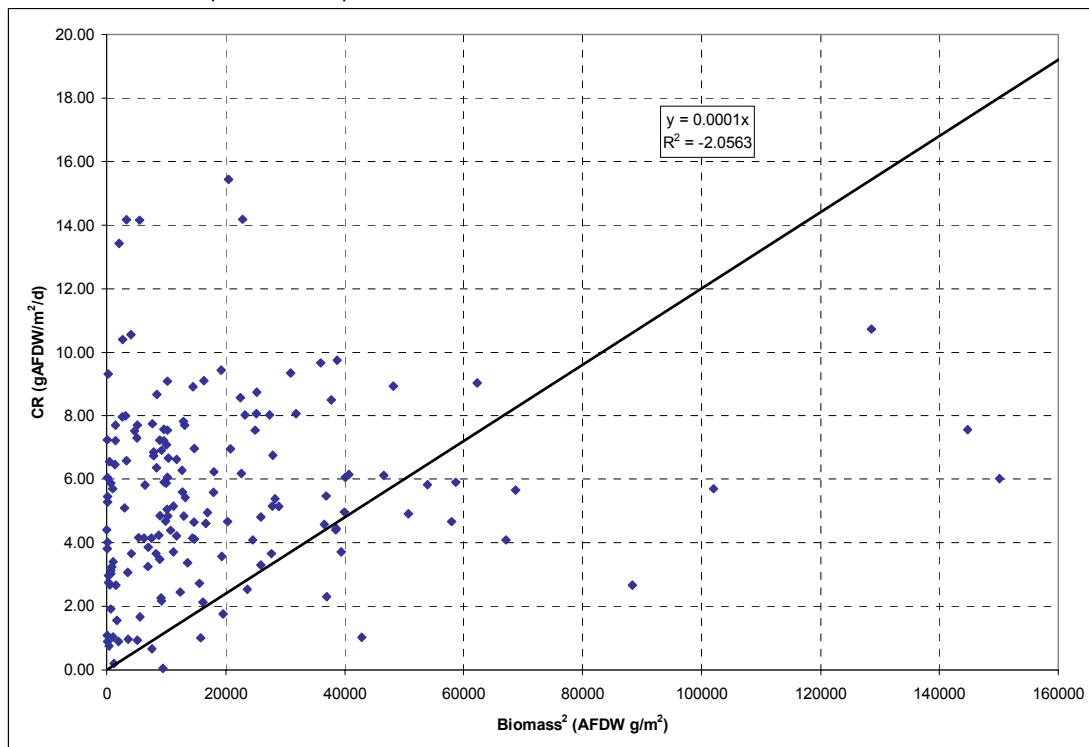
**4.3.4 Biomass Export Rate ( $k_e$ )**

Exhibit 4-8 shows the relationship between observed values for outflow volatile suspended solids (VSS) concentration and biomass. It is assumed that any VSS in the outflow represents sloughed biomass. VSS is estimated using the VSS/TSS ratio (0.184) determined from diel studies conducted at the Porta-PSTA and South Test Cell shellrock treatments in October 1999 (CH2M HILL, August 2000). The slope of the regression line ( $0.0002\text{ d}^{-1}$ ) was used as the initial model value for  $k_e$ .

**4.3.5 Biomass Accretion Rate ( $k_a$ )**

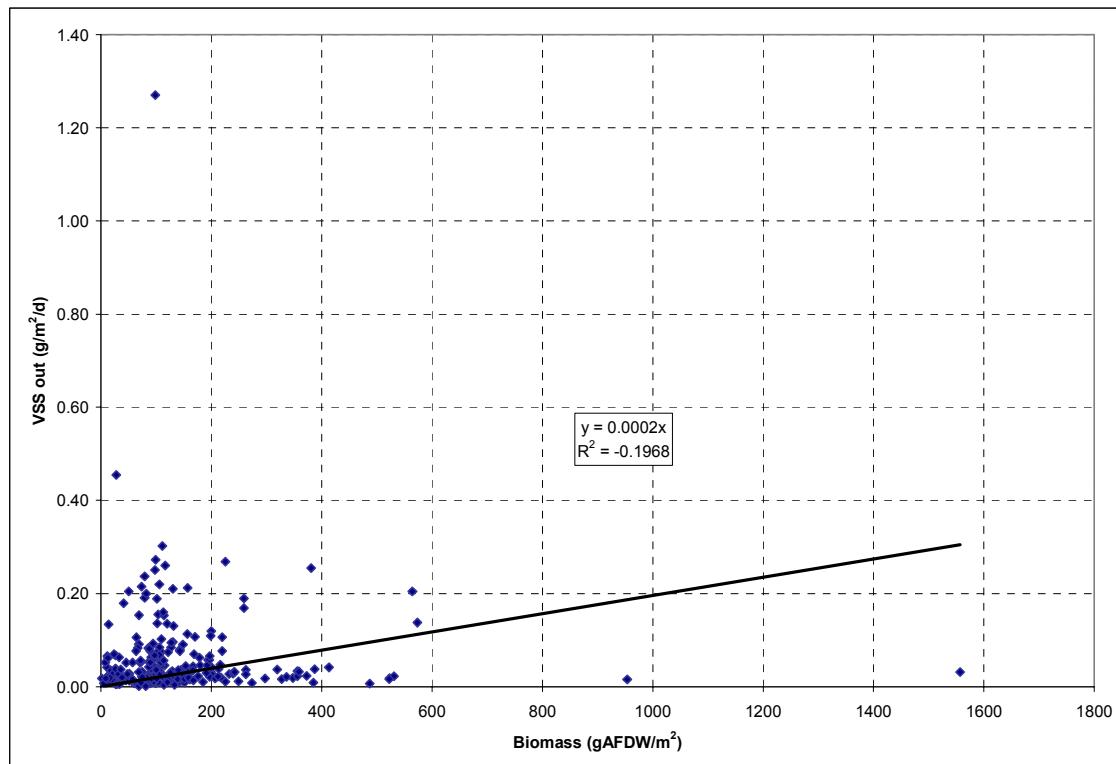
The rate of biomass accretion ( $k_a$ ) at the sediment/water interface was not directly measured during the PSTA research. Horizon markers could not be recovered after an 18-month operational period. Sediment traps were used to estimate total accretion, but values were a better representation of gross accretion rather than net accretion. Because no direct measure of net biomass and TP accretion was possible, this rate coefficient is estimated through the model calibration described below.

**4.4 Model Calibration**

The PSTA Forecast Model was calibrated using POR data from the three PSTA Test Cells. These systems have been operated for nearly 2 years. However, the data available for calibration included only approximately 18 months (February 1999–October 2000). The model was calibrated separately for the three test systems because of their very different soil types and

**EXHIBIT 4-8**

## Observed Relationship Between Periphyton Biomass and the Export of VSS in the PSTA Shellrock Mesocosms



water regimes. Test Cell 8 provides a data set for a shellrock-based PSTA with stable water levels. Test Cell 3 represents a shellrock PSTA with fluctuating water depths, including dry-out. Test Cell 13 data are applicable to a PSTA built on organic soils with high antecedent soil P concentrations.

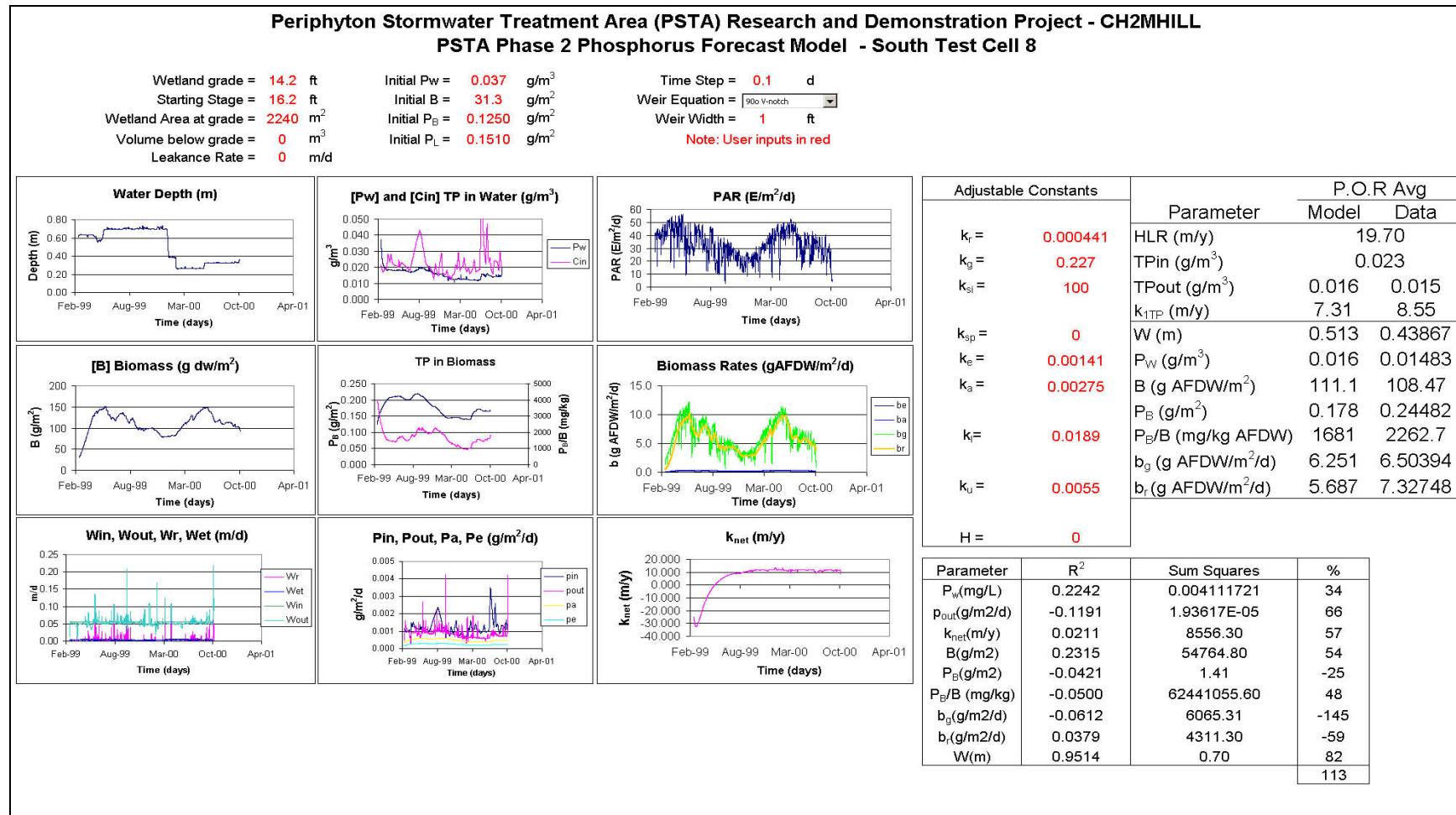
Calibration was conducted as a preliminary fit of the actual and model data using the rate constants described previously. Goodness of fit was determined by calculating the sum of squares of differences between individual records of  $P_w$ ,  $P_{out}$ ,  $k_{net}$ ,  $B$ ,  $P_B$ ,  $P_B/B$ ,  $b_g$ ,  $b_r$ , and  $W$ . Solver was used to automatically optimize adjustable coefficients to provide the lowest total sum of these individual sums of squares. POR average values for the actual data and the model were also calculated and referred to during model calibration.

Exhibit 4-9 illustrates a representative PSTA Forecast Model calibration sheet for Test Cell 8. An accompanying sheet was used to overlay model and actual values for a visual assessment of goodness of fit (see Exhibit 4-10). The ability to correlate the model output to actual data from multiple measured parameters provided significant power in calibration. Model calibration data sheets for the PSTA Test Cells are included in Appendix E.

Exhibits 4-11 through 4-13 illustrate calibrated model fits for each of the three PSTA data sets (Test Cell 3 [shellrock, variable water], Test Cell 8 [shellrock, constant water], and Test Cell 13 [peat, constant water, soil amendment], respectively). Comparisons between actual data and model output are shown for  $W$ ,  $TP_{out}$ ,  $k_{net}$ , and  $b_g$ . All of the general trends in the actual data are reasonably well simulated by the PSTA Forecast Model.

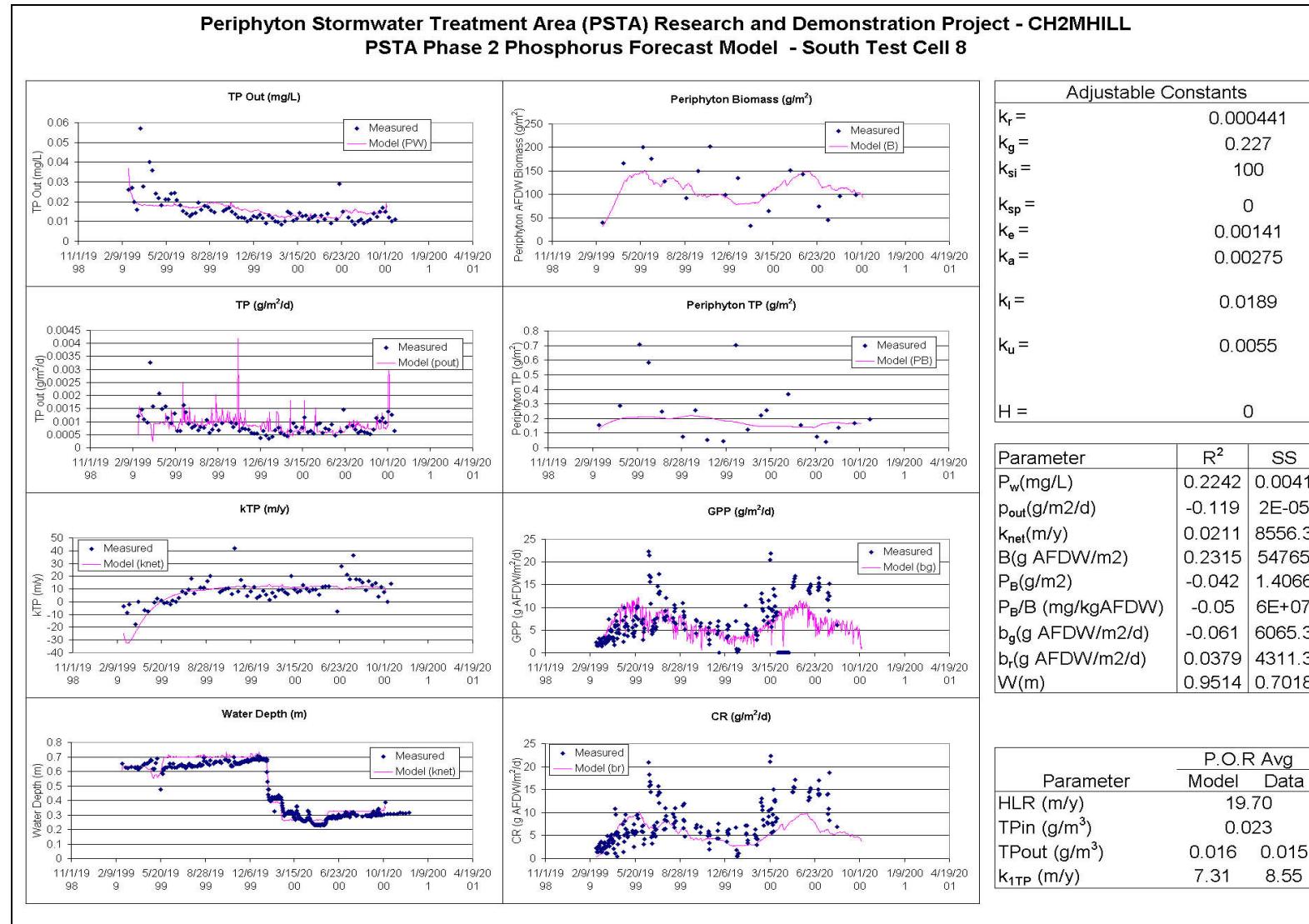
**EXHIBIT 4-9**

Example PSTA Forecast Model Calibration Spreadsheet Illustrating PSTA Test Cell 8 Input Parameters and Model Output



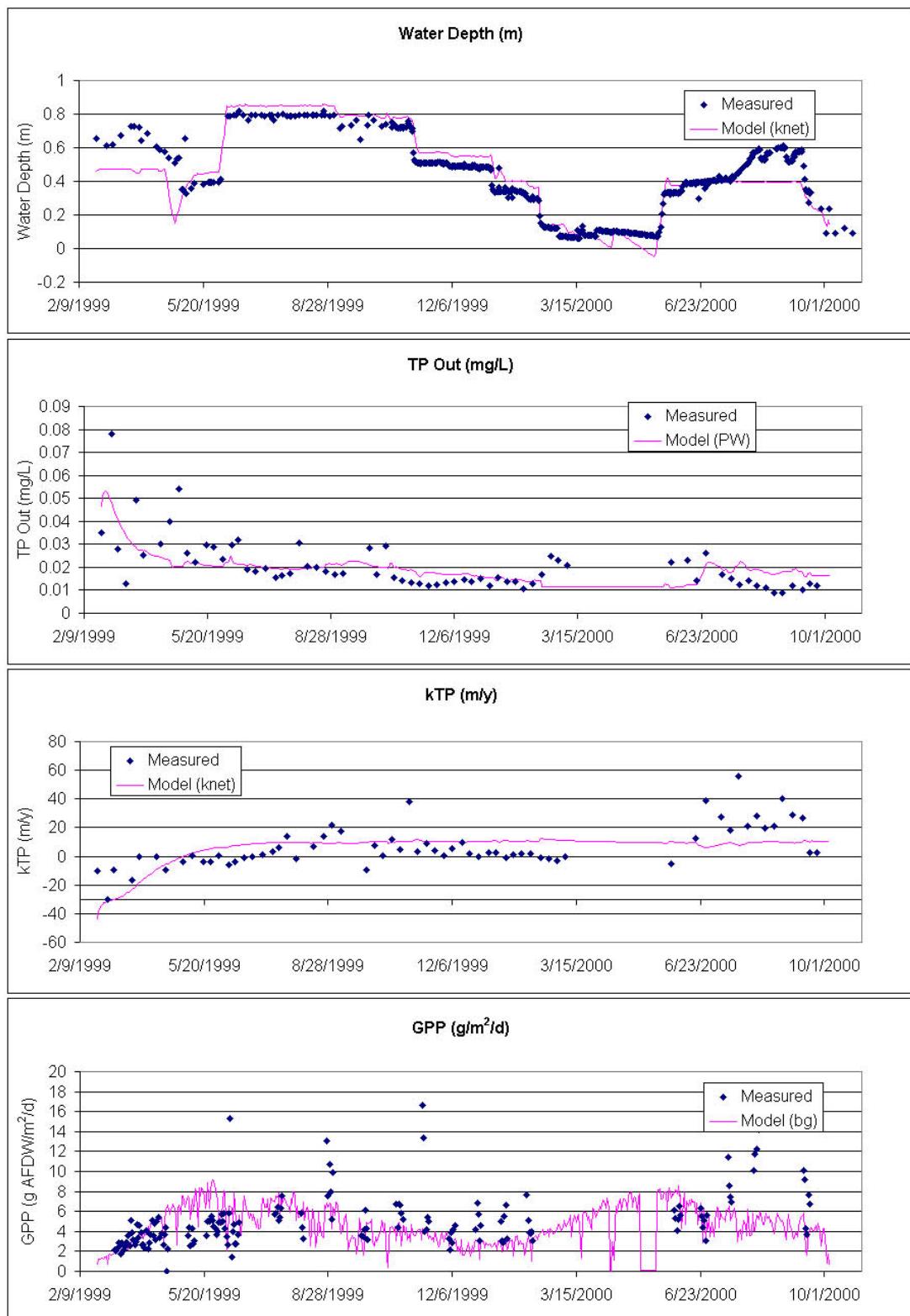
**EXHIBIT 4-10**

Example PSTA Forecast Model Calibration Spreadsheet Illustrating Actual and Predicted Results for PSTA Test Cell 8



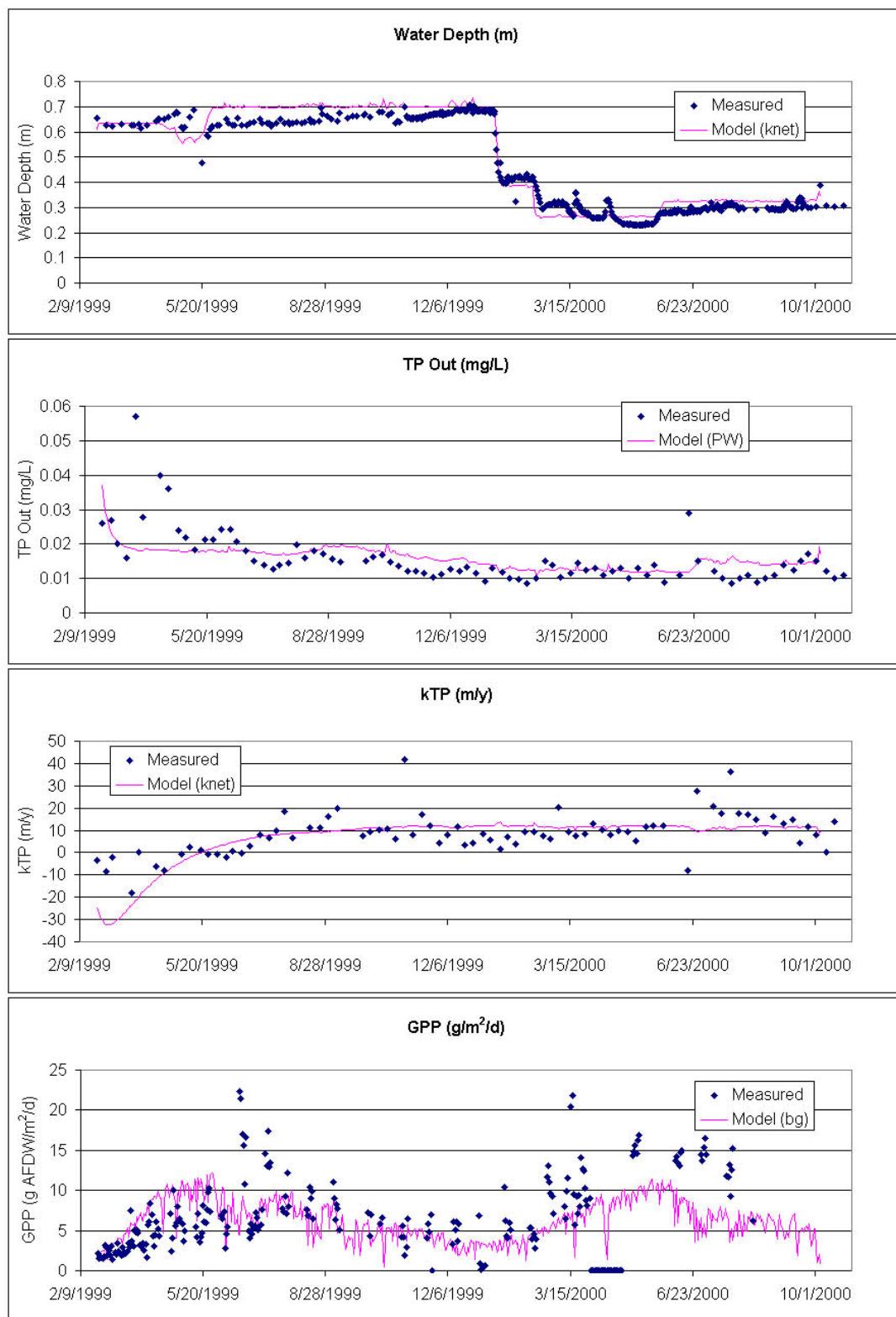
**EXHIBIT 4-11**

Detailed Comparison of PSTA Forecast Model Estimates and Actual Data from PSTA Test Cell 3 – Shellrock  
Variable Water Regime



**EXHIBIT 4-12**

Detailed Comparison of PSTA Forecast Model Estimates and Actual Data from PSTA Test Cell 8 – Shellrock Constant Water Regime



**EXHIBIT 4-13**

Detailed Comparison of PSTA Forecast Model Estimates and Actual Data from PSTA Test Cell 13 – Peat, Constant Water Regime, Soil Amendment

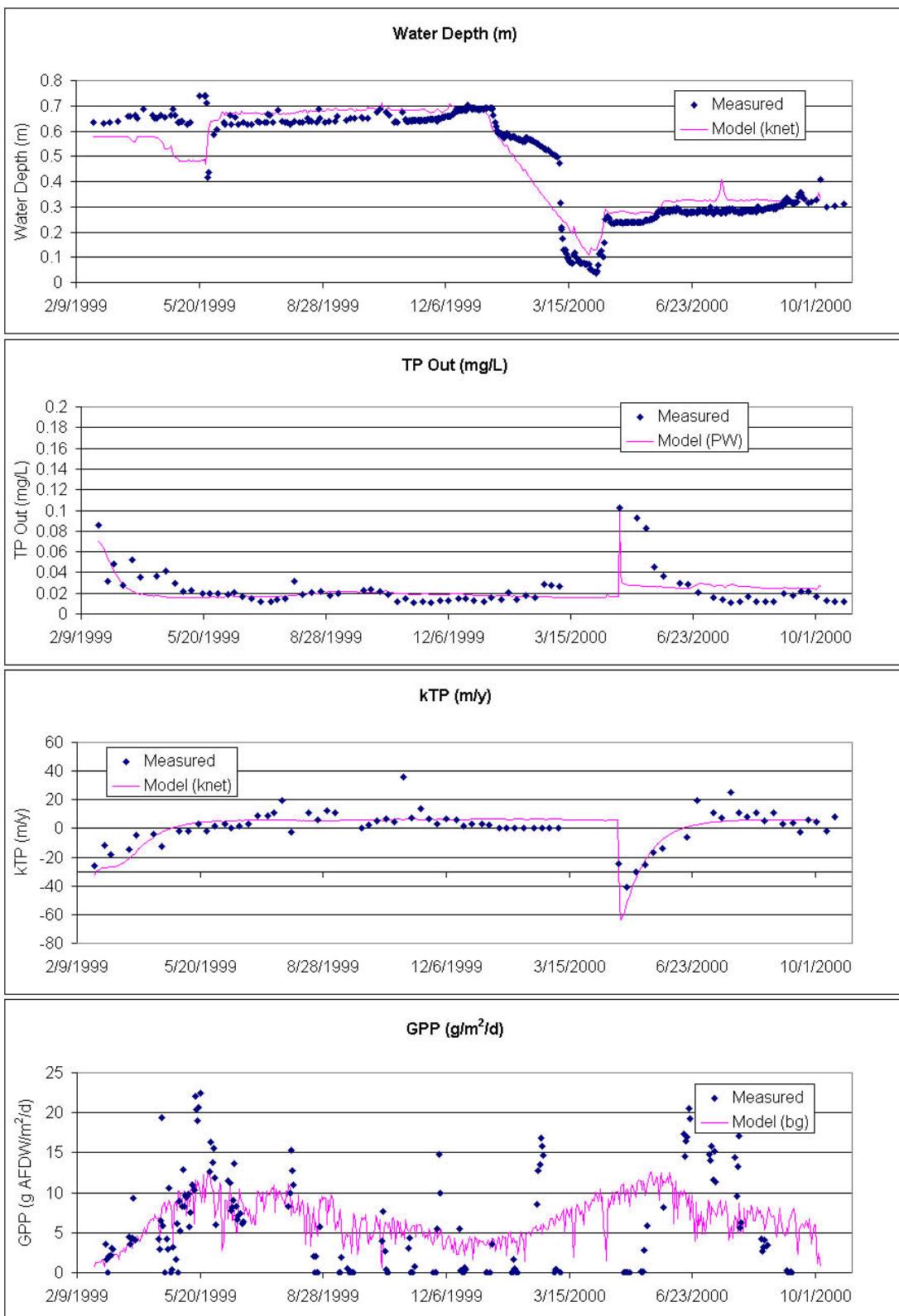


Exhibit 4-14 provides values for all of the adjustable coefficients and initial conditions for each of the calibration data sets. A relatively small range in calibrated model coefficients was found between the three PSTA Test Cells. The calibrated periphyton growth and respiration rates were highest in PSTA Test Cell 8, the constant water level shellrock treatment. Estimated  $k_a$  was more than 1.5 times higher in both shellrock treatments compared to the peat treatment. The highest TP release from labile storage was estimated for the peat-based PSTA Test Cell.

Exhibits 4-15 through 4-17 provide the results of a sensitivity analysis of the adjustable coefficients for each of the three calibrated models, respectively. Each coefficient was tested at one-half and at twice its calibrated value. The coefficients that consistently resulted in the largest changes in  $k_{net}$  and  $TP_{out}$  were  $k_r$ ,  $k_l$ , and  $k_u$ . The peat-based PSTA model was more sensitive to changes in rate constants than either of the shellrock wetlands. The biological state variables of B and rates of productivity and respiration are most affected by changes to the biomass growth and respiration rates ( $k_g$  and  $k_r$ , respectively) and the light half saturation constant ( $k_{si}$ ).

## 4.5 Model Simulations

### 4.5.1 Effects of Different Forcing Functions

The PSTA Forecast Model has been tested for five general operational/management alternatives. These include the following hypothetical scenarios:

- PSTAs constructed on a leaky site with a vertical leakance rate of 0.02 m/d
- PSTAs receiving a steady inflow TP concentration of 100 parts per billion (ppb)
- PSTAs receiving a steady inflow TP concentration of 50 ppb
- PSTAs with a harvest rate (H) of 0.001 d<sup>-1</sup>
- PSTAs with a harvest rate of 0.0001 d<sup>-1</sup>

A matrix of the above factors was examined to provide an overall picture of model response. All three calibration data sets were used for these model simulations. Existing inflow TP and environmental data were copied to provide a synthetic 5-year input data set (for Test Cells 8 and 13). Stable water depths of 30 cm and inflow rates of 134 m<sup>3</sup>/d were tested. For the Test Cell 3 calibration data set, the existing 18-month flow and water depth fluctuation was projected into a repeating cycle through the 5-year simulation period. Detailed output from each of these 36 model simulations is provided in Appendix F. A summary of the model output is provided in Exhibit 4-18.

A simulated average vertical leakance rate of 2 cm/d resulted in a very slight increase in  $k_l$  and no significant decrease in  $TP_{out}$  for each of the PSTA configurations tested.

Harvesting at a rate of 3.65 percent per year ( $H = 0.0001 \text{ d}^{-1}$ ) provided no measurable improvement in long-term average PSTA outlet TP concentrations. Harvesting periphyton at a rate of 36.5 percent per year ( $H = 0.001 \text{ d}^{-1}$  or approximately 7.3 wet mt/ha per year or approximately 70 g dry weight/m<sup>2</sup>/y) only lowered projected TP outflow concentrations by approximately 1 to 2 ppb. Additional model runs (not illustrated in Exhibit 4-18) indicated that for harvesting to increase  $k_l$  to approximately 17 m/y and  $TP_{out}$  less than 10 ppb for the

**EXHIBIT 4-14**

## Comparison of PSTA Forecast Model Initial Values and Adjustable Coefficients for PSTA Test Cells

	Data		
	Test Cell 3 (shellrock)	Test Cell 8 (shellrock)	Test Cell 13 (peat)
Wetland Grade	14.3	14.2	14.3
Starting Stage	15.8	16.2	16.2
Wet Area (m <sup>2</sup> )	2240	2240	2240
Initial w (g/m <sup>3</sup> )	0.047	0.037	0.070
Initial Biomass (g/m <sup>2</sup> )	24.1	31.3	23.8
Initial P in Biomass (g/m <sup>2</sup> )	0.143	0.125	0.040
Initial Labile P (g/m <sup>2</sup> )	0.177	0.151	0.120
K <sub>r</sub> (m <sup>2</sup> /gAFDW/d)	0.00028	0.00044	0.00023
K <sub>g</sub> (d <sup>-1</sup> )	0.165	0.227	0.171
K <sub>g</sub> <sup>1</sup> (E/m <sup>2</sup> /d)	100	100	100
K <sub>sp</sub> (g TP/ m <sup>3</sup> )	0	0	0
K <sub>e</sub> (d <sup>-1</sup> )	0.00081	0.00141	0.00000
K <sub>a</sub> (d <sup>-1</sup> )	0.0024	0.0027	0.0015
K <sub>i</sub> (d <sup>-1</sup> )	0.033	0.018	0.051
K <sub>u</sub> (m <sup>3</sup> /gAFDW/d)	0.0034	0.0055	0.0025

Test Cell 8 base case, it would be necessary to harvest approximately 73 wet mt/ha/y ( $H = 0.01 \text{ d}^{-1}$ ).

Exhibit 4-18 also illustrates the modeled predictions for higher inflow TP concentrations of 50 and 100 ppb. For 100 ppb inflow, it is projected that a PSTA system built on shellrock would achieve an average outflow concentration of approximately 56 ppb if water levels were constant and approximately 61 ppb under variable water levels. The respective k<sub>1</sub> values are estimated as approximately 13 and 10 m/y for these two cases.

#### 4.5.2 Simulation Using STA-2 Synthetic Data Set

The District's synthetic post-STA-2 data set was used to provide a preview of PSTA performance for a 10-year period of variable inflows and TP concentrations. The average TP concentration into the PSTA for this period is approximately 37 ppb, and the flow-weighted mean inflow concentration is 50 ppb. Based on a weir height of 30 cm, the average water depth during this period was estimated as 55 cm, based on a 7.6-meter-wide horizontal weir. The average inflow rate for this data set is approximately 531,000 m<sup>3</sup>/d.

## EXHIBIT 4-15

## Sensitivity Analysis of Adjustable Coefficients for Test Cell 3

Adjustable Constants	Initial Value	Percent Adjustment	Adjusted Value	Actual Data Averages Model Averages Delta (%)	HLR (m/y)	TP <sub>in</sub> (g/m <sup>3</sup> )	TP <sub>out</sub> (g/m <sup>3</sup> )	k <sub>1TP</sub> (m/y)	W (m)	B (g AFDW /m <sup>2</sup> )	P <sub>B</sub> (g/m <sup>2</sup> )	P <sub>B/B</sub> (mg/kg AFDW)	b <sub>g</sub> (g AFDW /m <sup>2</sup> /d)	b <sub>r</sub> (g AFDW /m <sup>2</sup> /d)
				19.3 0.023 <b>0.0</b>	19.3 0.023 <b>0.0</b>	0.019 0.019 <b>-1.3</b>	3.4 3.6 <b>7.5</b>	0.40 0.47 <b>16.3</b>	103 119 <b>15.8</b>	0.207 0.192 <b>-7.3</b>	2544 1770 <b>-30.4</b>	5.6 4.6 <b>-17.8</b>	5.6 4.1 <b>-26.8</b>	
k <sub>r</sub>	0.000286	50%	0.000429	Model Delta (%) 0.0 0.0 <b>17.3</b>	19.3 0.023 <b>0.0</b>	0.022 0.022 <b>-90.9</b>	0.3 0.47 <b>16.3</b>	0.47 -21.2 <b>16.3</b>	81 -21.2 <b>21.2</b>	0.157 -24.2 <b>-24.2</b>	2060 -19.0 <b>-19.0</b>	3.2 8.8 <b>-43.8</b>	2.8 7.8 <b>-49.6</b>	
		-50%	0.000143	Model Delta (%) 0.0 0.0 <b>-31.6</b>	19.3 0.023 <b>0.0</b>	0.013 0.013 <b>-31.6</b>	10.7 217.3 <b>217.3</b>	0.47 16.3 <b>16.3</b>	229 123.7 <b>123.7</b>	0.249 20.3 <b>20.3</b>	1287 -49.4 <b>-49.4</b>	8.8 57.3 <b>57.3</b>	7.8 39.0 <b>39.0</b>	
k <sub>g</sub>	0.165	50%	0.247	Model Delta (%) 0.0 0.0 <b>-2.7</b>	19.3 0.023 <b>0.0</b>	0.018 0.018 <b>-2.7</b>	3.9 15.5 <b>16.3</b>	0.47 16.3 <b>16.3</b>	186 81.8 <b>81.8</b>	0.196 -5.1 <b>-5.1</b>	1185 -53.4 <b>-53.4</b>	10.9 94.9 <b>94.9</b>	10.1 81.0 <b>81.0</b>	
		-50%	0.082	Model Delta (%) 0.0 0.0 <b>2.9</b>	19.3 0.023 <b>0.0</b>	0.019 0.019 <b>2.9</b>	2.8 -16.2 <b>16.3</b>	0.47 16.3 <b>16.3</b>	53 -48.2 <b>-48.2</b>	0.182 -12.0 <b>-12.0</b>	3544 39.3 <b>39.3</b>	1.0 -81.7 <b>-81.7</b>	0.8 -85.6 <b>-85.6</b>	
k <sub>si</sub>	100	50%	150	Model Delta (%) 0.0 0.0 <b>0.2</b>	19.3 0.023 <b>0.0</b>	0.019 0.019 <b>-1.3</b>	3.3 16.3 <b>16.3</b>	0.47 -19.2 <b>16.3</b>	83 -19.2 <b>19.2</b>	0.188 -9.2 <b>-9.2</b>	2427 -4.6 <b>-4.6</b>	2.3 -58.3 <b>-58.3</b>	2.0 -64.5 <b>-64.5</b>	
		-50%	50	Model Delta (%) 0.0 0.0 <b>-2.8</b>	19.3 0.023 <b>0.0</b>	0.018 0.018 <b>-2.8</b>	3.9 16.0 <b>16.0</b>	0.47 16.3 <b>16.3</b>	199 94.1 <b>94.1</b>	0.197 -4.8 <b>-4.8</b>	1111 -56.3 <b>-56.3</b>	12.4 120.0 <b>120.0</b>	11.5 105.0 <b>105.0</b>	
k <sub>e</sub>	0.000819	50%	0.001228	Model Delta (%) 0.0 0.0 <b>-4.3</b>	19.3 0.023 <b>0.0</b>	0.018 0.018 <b>-4.3</b>	4.2 25.0 <b>25.0</b>	0.47 16.3 <b>16.3</b>	117 14.5 <b>14.5</b>	0.184 -11.2 <b>-11.2</b>	1721 -32.3 <b>-32.3</b>	4.6 -18.7 <b>-18.7</b>	4.0 -28.5 <b>-28.5</b>	
		-50%	0.000409	Model Delta (%) 0.0 0.0 <b>1.9</b>	19.3 0.023 <b>0.0</b>	0.019 0.019 <b>1.9</b>	3.0 -10.9 <b>16.3</b>	0.47 16.3 <b>16.3</b>	120 17.2 <b>17.2</b>	0.200 -3.1 <b>-3.1</b>	1823 -28.3 <b>-28.3</b>	4.7 -16.8 <b>-16.8</b>	4.2 -25.1 <b>-25.1</b>	
k <sub>a</sub>	0.00245	50%	0.00368	Model Delta (%) 0.0 0.0 <b>-9.6</b>	19.3 0.023 <b>0.0</b>	0.017 0.017 <b>-9.6</b>	5.3 57.5 <b>57.5</b>	0.47 16.3 <b>16.3</b>	115 11.7 <b>11.7</b>	0.169 -18.1 <b>-18.1</b>	1634 -35.8 <b>-35.8</b>	4.5 -20.7 <b>-20.7</b>	3.8 -31.9 <b>-31.9</b>	
		-50%	0.00123	Model Delta (%) 0.0 0.0 <b>9.2</b>	19.3 0.023 <b>0.0</b>	0.021 0.021 <b>9.2</b>	1.7 -50.4 <b>16.3</b>	0.47 16.3 <b>16.3</b>	123 20.0 <b>20.0</b>	0.220 6.3 <b>6.3</b>	1942 -23.6 <b>-23.6</b>	4.8 -14.9 <b>-14.9</b>	4.4 -21.5 <b>-21.5</b>	
k <sub>i</sub>	0.0337	50%	0.0506	Model Delta (%) 0.0 0.0 <b>-0.9</b>	19.3 0.023 <b>0.0</b>	0.019 0.019 <b>-0.9</b>	3.5 5.3 <b>5.3</b>	0.47 16.3 <b>16.3</b>	119 15.8 <b>15.8</b>	0.190 -7.8 <b>-7.8</b>	1772 -30.4 <b>-30.4</b>	4.6 -17.8 <b>-17.8</b>	4.1 -26.8 <b>-26.8</b>	
		-50%	0.0169	Model Delta (%) 0.0 0.0 <b>-2.3</b>	19.3 0.023 <b>0.0</b>	0.018 0.018 <b>-2.3</b>	3.8 13.1 <b>13.1</b>	0.47 16.3 <b>16.3</b>	119 15.8 <b>15.8</b>	0.193 -6.8 <b>-6.8</b>	1766 -30.6 <b>-30.6</b>	4.6 -17.8 <b>-17.8</b>	4.1 -26.8 <b>-26.8</b>	
k <sub>u</sub>	0.00340	50%	0.00510	Model Delta (%) 0.0 0.0 <b>-20.7</b>	19.3 0.023 <b>0.0</b>	0.015 0.015 <b>-20.7</b>	7.8 132.4 <b>132.4</b>	0.47 16.3 <b>16.3</b>	119 15.8 <b>15.8</b>	0.229 10.7 <b>10.7</b>	2093 -17.7 <b>-17.7</b>	4.6 -17.8 <b>-17.8</b>	4.1 -26.8 <b>-26.8</b>	
		-50%	0.00170	Model Delta (%) 0.0 0.0 <b>30.6</b>	19.3 0.023 <b>0.0</b>	0.025 0.025 <b>30.6</b>	-1.8 -152.6 <b>-152.6</b>	0.47 16.3 <b>16.3</b>	119 15.8 <b>15.8</b>	0.130 -37.1 <b>-37.1</b>	1237 -51.4 <b>-51.4</b>	4.6 -17.8 <b>-17.8</b>	4.1 -26.8 <b>-26.8</b>	

## EXHIBIT 4-16

## Sensitivity Analysis of Adjustable Coefficients for Test Cell 8

Adjustable Constants	Initial Value	Percent Adjustment	Adjusted Value	Actual Data Averages Model Averages Delta (%)	HLR	TP <sub>in</sub>	TP <sub>out</sub>	k <sub>1TP</sub>	W	B	P <sub>B</sub>	P <sub>B/B</sub>	b <sub>g</sub>	b <sub>r</sub>
					(m/y)	(g/m <sup>3</sup> )	(g/m <sup>3</sup> )	(m/y)	(m)	(g AFDW /m <sup>2</sup> )	(g/m <sup>2</sup> )	(mg/kg AFDW)	(g AFDW /m <sup>2</sup> /d)	(g AFDW /m <sup>2</sup> /d)
k <sub>r</sub>	0.000442	50%	0.000662	Model	19.7	0.023	0.019	3.4	0.50	75	0.146	2015	4.3	3.9
		-50%	0.000221	Delta (%)	0.0	0.0	29.9	-60.1	14.1	-30.6	-40.2	-10.9	-34.4	-46.9
	0.227	50%	0.341	Model	19.7	0.023	0.016	7.6	0.50	172	0.180	1116	14.7	13.8
		-50%	0.114	Delta (%)	0.0	0.0	4.8	-10.8	14.1	58.9	-26.5	-50.7	125.8	87.8
k <sub>g</sub>	100	50%	150	Model	19.7	0.023	0.016	7.0	0.50	79	0.175	2317	3.3	2.9
		-50%	50	Delta (%)	0.0	0.0	8.5	-18.7	14.1	-27.4	-28.5	2.4	-50.0	-61.0
	0.001414	50%	0.002122	Model	19.7	0.023	0.015	8.4	0.50	110	0.166	1593	6.2	5.6
		-50%	0.000707	Delta (%)	0.0	0.0	0.9	-2.1	14.1	1.2	-32.2	-29.6	-4.5	-24.1
k <sub>a</sub>	0.00275	50%	0.00412	Model	19.7	0.023	0.015	8.3	0.50	110	0.167	1598	6.2	5.6
		-50%	0.00137	Delta (%)	0.0	0.0	1.2	-2.8	14.1	1.3	-32.0	-29.4	-4.4	-24.0
	0.0189	50%	0.0284	Model	19.7	0.023	0.019	3.5	0.50	116	0.223	2012	6.5	6.2
		-50%	0.0095	Delta (%)	0.0	0.0	29.1	-58.7	14.1	6.8	-9.1	-11.1	0.7	-15.6
k <sub>l</sub>	0.00550	50%	0.00825	Model	19.7	0.023	0.012	12.1	0.50	111	0.208	1963	6.3	5.7
		-50%	0.00275	Delta (%)	0.0	0.0	-16.3	41.0	14.1	2.6	-15.0	-13.3	-3.2	-22.0
	0.0	50%	0.0	Model	19.7	0.023	0.022	1.0	0.50	111	0.124	1179	6.3	5.7
		-50%	0.0	Delta (%)	0.0	0.0	46.5	-87.8	14.1	2.6	-49.5	-47.9	-3.2	-22.0

## EXHIBIT 4-17

## Sensitivity Analysis of Adjustable Coefficients for Test Cell 13

Adjustable Constants	Initial Value	Percent Adjustment	Adjusted Value	Actual Data Averages Model Averages Delta (%)	HLR	TP <sub>in</sub>	TP <sub>out</sub>	k <sub>1TP</sub>	W	B	P <sub>B</sub>	P <sub>B/B</sub>	b <sub>g</sub>	b <sub>r</sub>
					(m/y)	(g/m <sup>3</sup> )	(g/m <sup>3</sup> )	(m/y)	(m)	(g AFDW /m <sup>2</sup> )	(g/m <sup>2</sup> )	(mg/kg AFDW)	(g AFDW /m <sup>2</sup> /d)	(g AFDW /m <sup>2</sup> /d)
					16.9	0.023	0.024	-0.5	0.45	490	0.650	1547	6.2	6.7
k <sub>r</sub>	0.000230	50%	0.000345	Model	16.9	0.023	0.025	-1.3	0.49	108	0.163	1545	4.5	4.3
		-50%	0.000115	Delta (%)	0.0	0.0	4.6	177.2	10.6	-77.9	-75.0	-0.1	-26.9	-36.2
				Model	16.9	0.023	0.015	7.2	0.49	309	0.272	954	12.8	11.9
				Delta (%)	0.0	0.0	-36.6	-1664.9	10.6	-36.9	-58.1	-38.3	105.9	78.3
k <sub>g</sub>	0.171	50%	0.256	Model	16.9	0.023	0.021	1.5	0.49	247	0.209	899	15.6	14.9
		-50%	0.085	Delta (%)	0.0	0.0	-11.3	-428.8	10.6	-49.6	-67.9	-41.9	150.2	123.1
				Model	16.9	0.023	0.022	0.8	0.49	75	0.193	2602	1.5	1.3
				Delta (%)	0.0	0.0	-7.4	-273.5	10.6	-84.8	-70.3	68.3	-75.3	-80.0
k <sub>si</sub>	100	50%	150	Model	16.9	0.023	0.022	1.1	0.49	113	0.200	1813	3.4	3.1
		-50%	50	Delta (%)	0.0	0.0	-9.2	-342.6	10.6	-76.9	-69.3	17.2	-44.8	-53.2
				Model	16.9	0.023	0.021	1.5	0.49	263	0.209	841	17.5	16.8
				Delta (%)	0.0	0.0	-11.4	-432.5	10.6	-46.3	-67.8	-45.6	181.4	151.4
k <sub>e</sub>	0	50%	0	Model	16.9	0.023	0.020	2.4	0.49	157	0.187	1250	6.5	6.0
		-50%	0	Delta (%)	0.0	0.0	-16.0	-630.8	10.6	-68.0	-71.3	-19.1	5.0	-10.3
				Model	16.9	0.023	0.019	3.5	0.49	153	0.172	1180	6.4	5.7
				Delta (%)	0.0	0.0	-20.9	-852.8	10.6	-68.7	-73.5	-23.7	3.0	-13.8
k <sub>a</sub>	0.00158	50%	0.00236	Model	16.9	0.023	0.020	2.5	0.49	156	0.186	1247	6.5	6.0
		-50%	0.00079	Delta (%)	0.0	0.0	-16.3	-642.5	10.6	-68.1	-71.4	-19.4	4.9	-10.5
				Model	16.9	0.023	0.023	0.0	0.49	163	0.226	1437	6.8	6.5
				Delta (%)	0.0	0.0	-2.9	-98.9	10.6	-66.7	-65.3	-7.1	9.3	-3.0
k <sub>i</sub>	0.0519	50%	0.0779	Model	16.9	0.023	0.022	1.2	0.49	160	0.204	1336	6.7	6.2
		-50%	0.0260	Delta (%)	0.0	0.0	-9.9	-371.4	10.6	-67.4	-68.7	-13.6	7.1	-6.8
				Model	16.9	0.023	0.021	1.5	0.49	160	0.204	1325	6.7	6.2
				Delta (%)	0.0	0.0	-11.2	-426.1	10.6	-67.4	-68.6	-14.3	7.1	-6.8
k <sub>u</sub>	0.00253	50%	0.00379	Model	16.9	0.023	0.018	4.7	0.49	160	0.250	1624	6.7	6.2
		-50%	0.00126	Delta (%)	0.0	0.0	-26.6	-1124.3	10.6	-67.4	-61.6	5.0	7.1	-6.8
				Model	16.9	0.023	0.027	-2.8	0.49	160	0.131	869	6.7	6.2
				Delta (%)	0.0	0.0	14.6	509.7	10.6	-67.4	-79.8	-43.8	7.1	-6.8

**EXHIBIT 4-18**

PSTA Forecast Model Performance Under Selected Test Conditions (Vertical Leakage, Harvest, and Elevated Inflow TP Concentrations)

Parameter	Baseline			Vertical Leakage = 0.02 m/d			Harvest = 0.001 d <sup>-1</sup>			Harvest = 0.0001 d <sup>-1</sup>		
	TC 3	TC 8	TC 13	TC 3	TC 8	TC 13	TC 3	TC 8	TC 13	TC 3	TC 8	TC 13
<b>Inflow TP concentration = variable 5 year</b>												
HLR (m/y)	20.68	21.90	21.90	20.68	21.90	21.90	20.68	21.90	21.90	20.68	21.90	21.90
TPin (g/m <sup>3</sup> )	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
P <sub>w</sub> (g/m <sup>3</sup> )	0.0169	0.0139	0.0186	0.0165	0.0139	0.0186	0.0155	0.0128	0.0167	0.0168	0.0138	0.0184
k <sub>1TP</sub> (m/y)	4.83	9.40	3.05	5.31	9.41	3.06	6.61	11.26	5.40	5.02	9.60	3.31
W (m)	0.4195	0.3588	0.3588	0.2205	0.3527	0.3527	0.4195	0.3588	0.3588	0.4195	0.3588	0.3588
B (g AFDW/m <sup>2</sup> )	116.75	107.22	159.38	103.80	107.22	159.38	113.10	104.99	155.12	116.38	107.00	158.96
P <sub>B</sub> (g/m <sup>2</sup> )	0.1806	0.1590	0.1899	0.1691	0.1589	0.1898	0.1607	0.1430	0.1657	0.1784	0.1572	0.1872
P <sub>B/B</sub> (mg/kg AFDW)	1630.4	1545.8	1240.4	1661.2	1545.6	1239.9	1501.3	1421.7	1115.7	1616.2	1532.1	1226.3
b <sub>g</sub> (g AFDW/m <sup>2</sup> /d)	4.2024	5.7489	6.3875	2.9400	5.7489	6.3875	4.0722	5.6317	6.2187	4.1894	5.7372	6.3706
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.7801	5.2706	6.0746	2.5600	5.2706	6.0746	3.5507	5.0590	5.7600	3.7568	5.2492	6.0427
<b>Inflow TP concentration = 0.050 g/m<sup>3</sup></b>												
HLR (m/y)	20.68	21.90	21.90	20.68	21.90	21.90	20.68	21.90	21.90	20.68	21.90	21.90
TPin (g/m <sup>3</sup> )	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
P <sub>w</sub> (g/m <sup>3</sup> )	0.0324	0.0291	0.0395	0.0311	0.0291	0.0395	0.0298	0.0267	0.0355	0.0321	0.0288	0.0390
k <sub>1TP</sub> (m/y)	8.97	11.87	5.16	9.81	11.88	5.17	10.67	13.71	7.50	9.15	12.06	5.42
W (m)	0.4195	0.3588	0.3588	0.2205	0.3527	0.3527	0.4195	0.3588	0.3588	0.4195	0.3588	0.3588
B (g AFDW/m <sup>2</sup> )	116.75	107.22	159.38	103.80	107.22	159.38	113.10	104.99	155.12	116.38	107.00	158.96
P <sub>B</sub> (g/m <sup>2</sup> )	0.3431	0.3293	0.4036	0.3133	0.3292	0.4035	0.3064	0.2963	0.3523	0.3391	0.3257	0.3978
P <sub>B/B</sub> (mg/kg AFDW)	3055.0	3183.3	2602.6	3071.0	3181.6	2602.2	2820.3	2928.5	2339.4	3029.1	3155.3	2572.9
b <sub>g</sub> (g AFDW/m <sup>2</sup> /d)	4.2024	5.7489	6.3875	2.9400	5.7489	6.3875	4.0722	5.6317	6.2187	4.1894	5.7372	6.3706
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.7801	5.2706	6.0746	2.5600	5.2706	6.0746	3.5507	5.0590	5.7600	3.7568	5.2492	6.0427
<b>Inflow TP concentration = 0.100 g/m<sup>3</sup></b>												
HLR (m/y)	20.68	21.90	21.90	20.68	21.90	21.90	20.68	21.90	21.90	20.68	21.90	21.90
TPin (g/m <sup>3</sup> )	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
P <sub>w</sub> (g/m <sup>3</sup> )	0.0614	0.0556	0.0761	0.0588	0.0556	0.0761	0.0566	0.0511	0.0684	0.0608	0.0551	0.0752
k <sub>1TP</sub> (m/y)	10.10	12.87	5.99	10.99	12.87	5.99	11.78	14.70	8.33	10.28	13.06	6.24
W (m)	0.4195	0.3588	0.3588	0.2205	0.3527	0.3527	0.4195	0.3588	0.3588	0.4195	0.3588	0.3588
B (g AFDW/m <sup>2</sup> )	116.75	107.22	159.38	103.80	107.22	159.38	113.10	104.99	155.12	116.38	107.00	158.96
P <sub>B</sub> (g/m <sup>2</sup> )	0.6498	0.6284	0.7794	0.5904	0.6284	0.7794	0.5806	0.5655	0.6805	0.6422	0.6215	0.7683
P <sub>B/B</sub> (mg/kg AFDW)	5747.0	6066.8	5004.3	5767.9	6066.7	5004.0	5306.6	5581.5	4496.7	5698.4	6013.4	4947.0
b <sub>g</sub> (g AFDW/m <sup>2</sup> /d)	4.2024	5.7489	6.3875	2.9400	5.7489	6.3875	4.0722	5.6317	6.2187	4.1894	5.7372	6.3706
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.7801	5.2706	6.0746	2.5600	5.2706	6.0746	3.5507	5.0590	5.7600	3.7568	5.2492	6.0427

Performance of the proposed PSTA was tested with a variety of PSTA footprint areas, ranging from 500 to 8,000 ha. Projected long-term average outflow concentrations from the PSTA Forecast Model were 24 ppb for the design loading rate of approximately 5.3 cm/d (1,000 ha). Exhibit 4-19 illustrates the model predictions for this base case. Model performance charts are provided in Appendix G.

At a higher loading rate of 11 cm/d (500 ha), the projected outflow TP average is 29 ppb. The preliminary PSTA Forecast Model estimates that the PSTA area must be increased to approximately 8,000 ha to achieve an average  $TP_{out}$  concentration of 10 ppb.

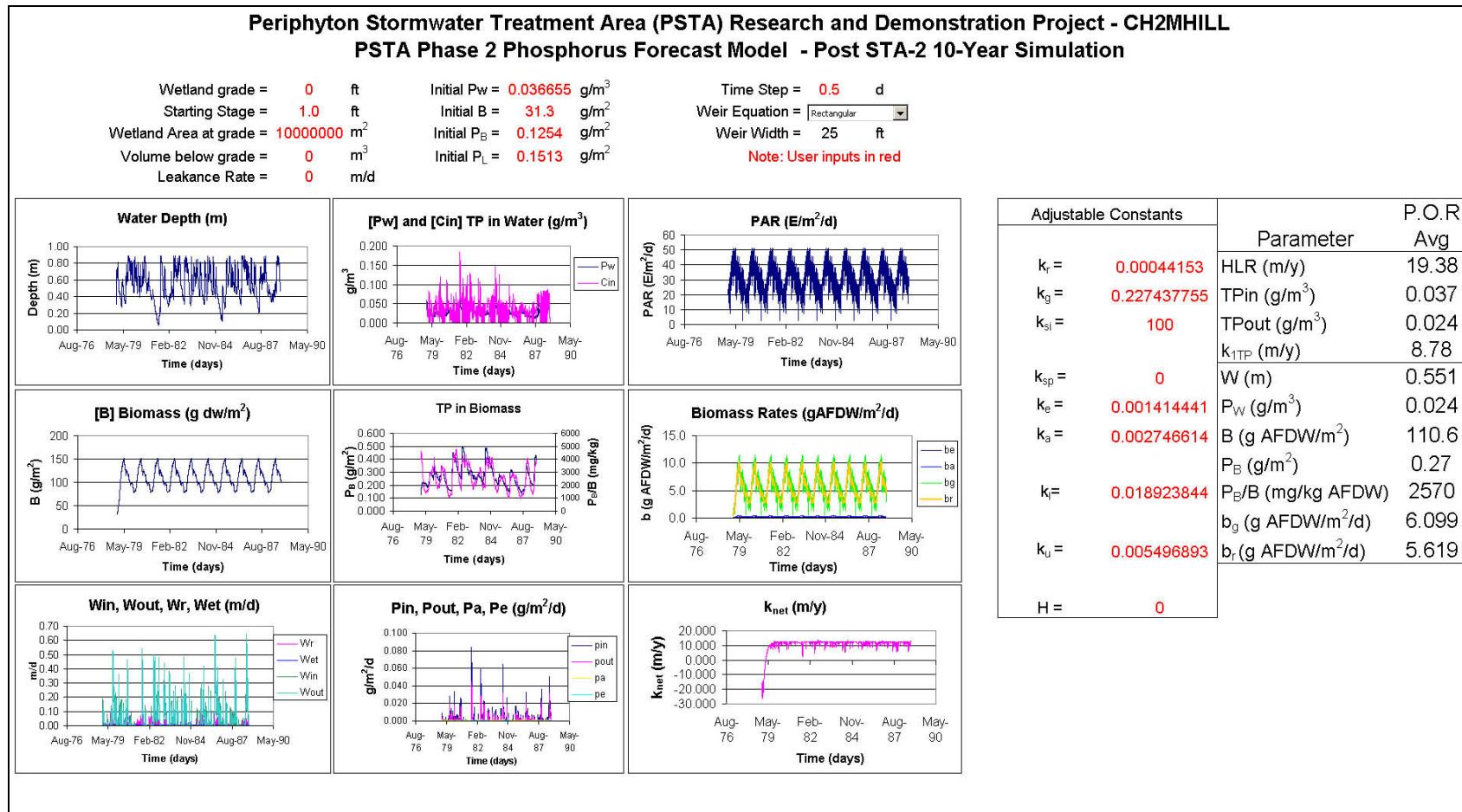
## 4.6 Potential PSTA Model Enhancements

The PSTA Forecast Model can be upgraded in the future based on continuing data collection. The full 2-year data set from the PSTA Test Cells will be used for a final model calibration for comparison to these preliminary results. Data from the Field-Scale PSTA should also be used to validate or modify the PSTA Forecast Model coefficients and performance.

A variety of changes could be made to the structure of the PSTA Forecast Model. These include additional work to simulate multiple PSTA cells in series. Research necessary to calibrate that model is not currently planned. Improved performance and lower outflow TP concentrations are likely to result from linking several PSTA cells in series. The PSTA model could also be upgraded by adding a macrophyte state variable. This addition would provide an integrated model that could be used to project the performance of a variable mixture of macrophytic and periphytic plant communities in an STA. During calibration of the PSTA Forecast Model, it was found that incorporation of biomass, community productivity, and community respiration were very important for simulating the behavior of P dynamics. Incorporation of sunlight and plant functional and structural measures in the DMSTA model would provide a better basis for estimating factors affecting performance of all of the potential green technologies.

**EXHIBIT 4-19**

PSTA Forecast Model Spreadsheet Illustrating Simulation Using Post STA-2 Synthetic Data Set



## SECTION 5

# References

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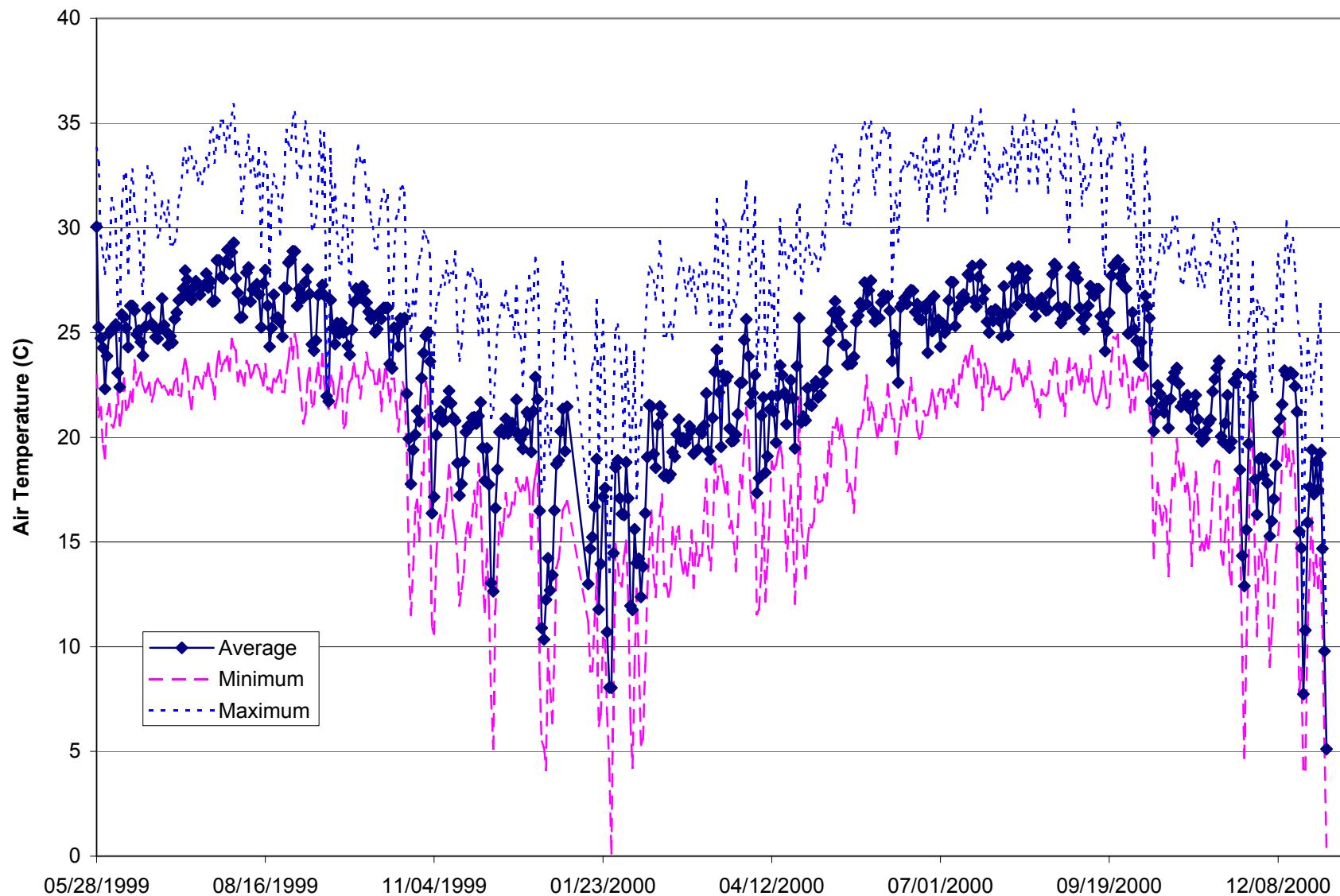
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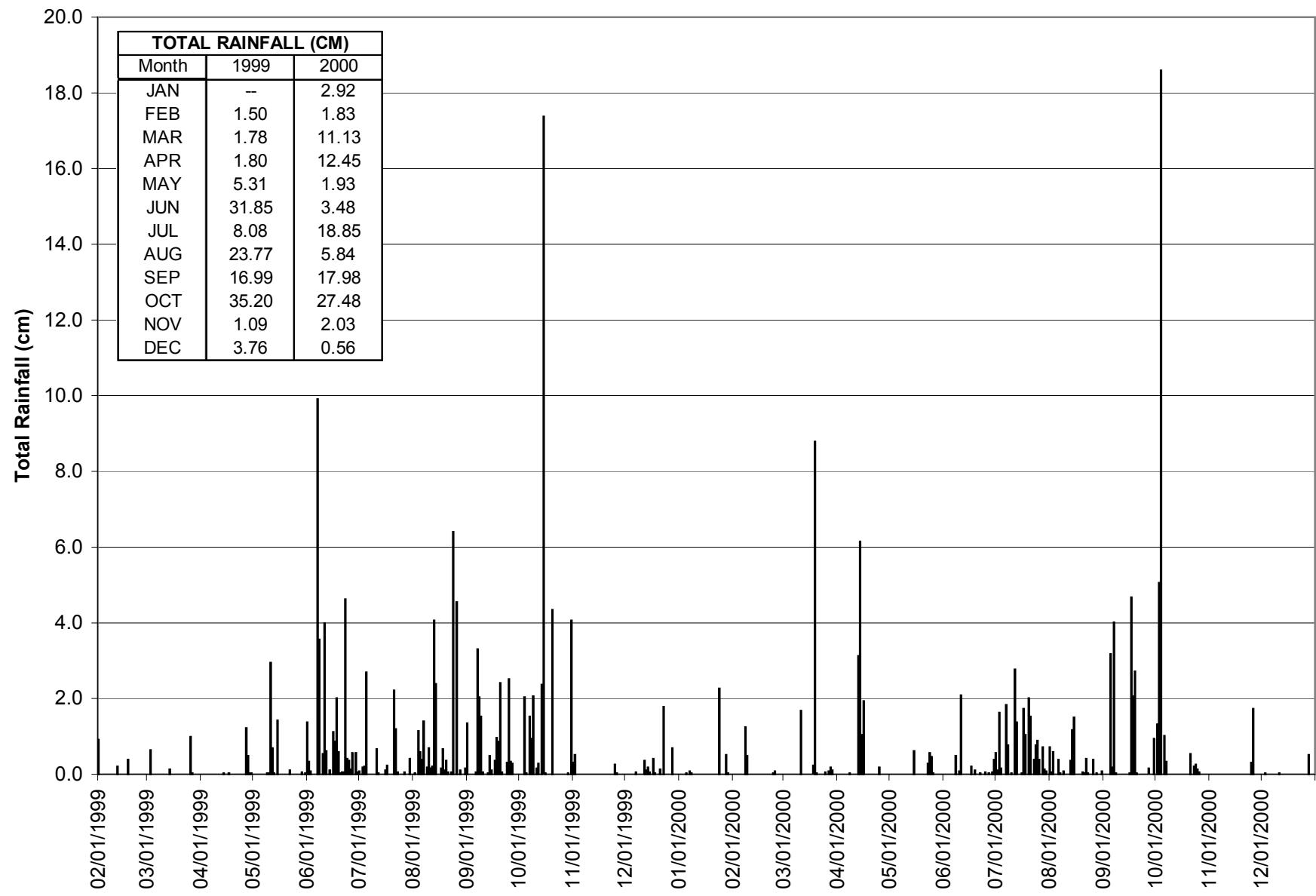
**APPENDIX A**

## **Meteorological Data**

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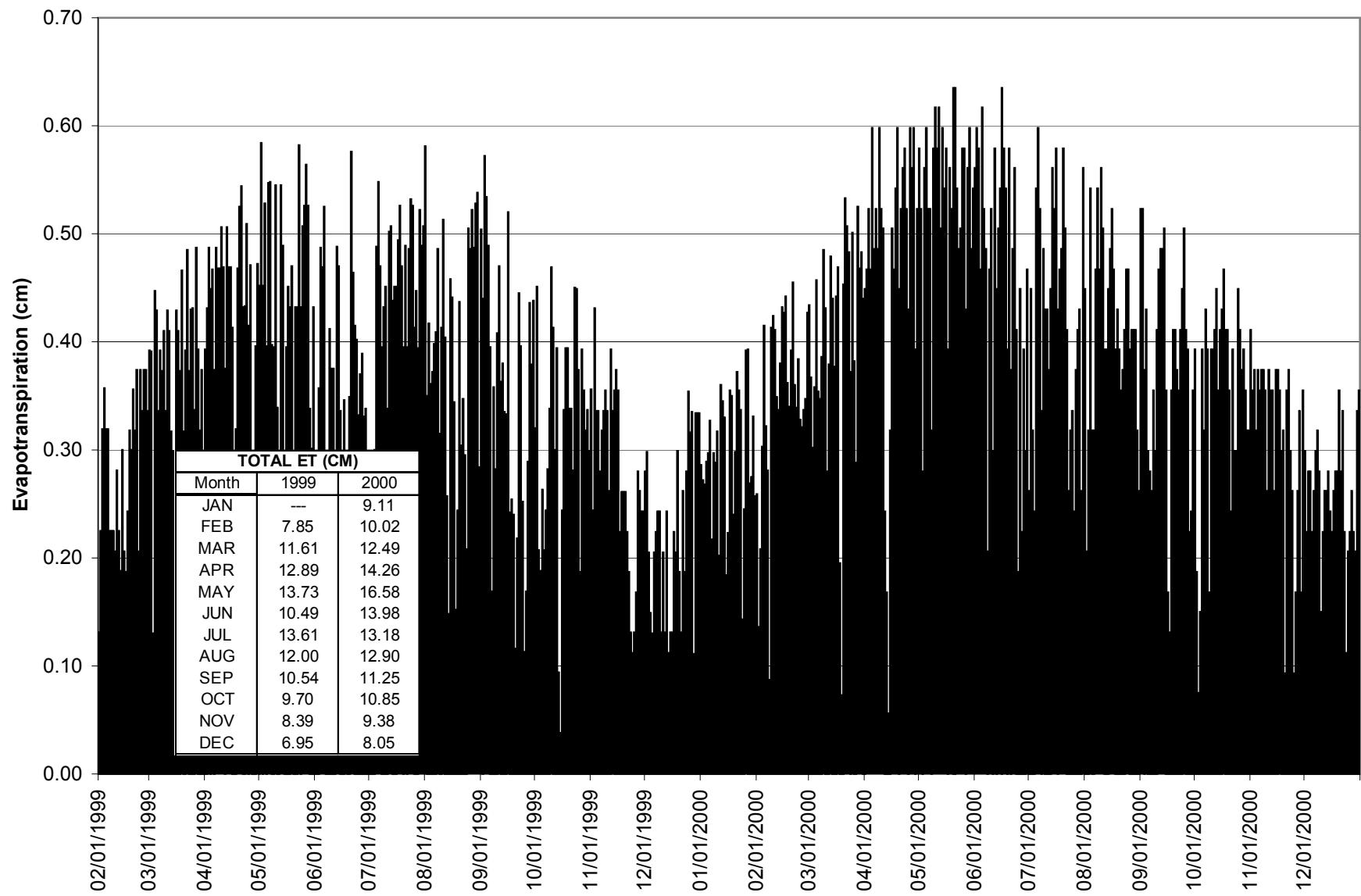
**EXHIBIT A-1**

Average Daily Air Temperature Data at the South ENR Technology Research Compound



#### EXHIBIT A-2

Daily Rainfall Data at the ENR Rainfall Station, ENR301



### EXHIBIT A-3

Daily Evaporation Data at the ENR Evapotranspiration Station ENRP

DFB/16518.xls

**APPENDIX B**

**ENR PSTA Test Cell Data**

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**Exhibit B-1**

Water Balances for the PSTA Test Cells, April - December 2000

Treatment	Cell	Month	Depth (m)	HLR (cm/d)	Inflow		Outflow		Rainfall		ET		ΔSTORAGE (m³)	Residual (m³)	Residual (% of inflow)
					(m³/d)	(m³)	(m³/d)	(m³)	(in)	(m³)	(mm)	(m³)			
4	13	Apr-00	0.147	4.60	121.930	3779.84	78.364	2429.29	4.90	287.74	142.60	329.68	422.10	567.33	13.95
		May-00	0.250	5.18	121.905	3779.05	106.876	3313.17	0.76	45.66	165.76	392.06	108.14	-248.66	-6.50
		Jun-00	0.282	5.20	121.816	3776.30	116.023	3596.70	1.37	83.02	139.80	333.53	3.27	-958.52	-24.84
		Jul-00	0.283	5.23	121.929	3779.79	91.577	2838.89	7.42	450.02	131.78	314.66	-14.92	-57.64	-1.36
		Aug-00	0.289	5.32	121.886	3778.45	93.417	2895.92	2.30	139.68	129.00	308.43	46.64	-310.05	-7.91
		Sep-00	0.327	5.31	121.991	3781.72	108.241	3355.48	7.08	434.13	112.51	271.61	97.18	-420.63	-9.04
		Oct-00	0.327	5.50	121.990	3781.69	145.573	4512.76	10.82	663.76	108.45	261.93	-77.30	-251.94	-5.67
		Nov-00	0.302	4.94	122.010	3782.31	114.893	3561.68	0.80	48.75	93.83	225.11	-39.49	83.76	2.19
		Dec-00	0.283	4.47	121.811	3776.14	91.722	2843.38	0.22	13.33	80.53	192.15	-21.82	775.76	20.47
5	8	Apr-00	0.263	4.70	123.190	3818.89	146.430	4539.32	4.90	295.94	142.60	339.07	-66.13	727.80	17.69
		May-00	0.242	4.82	123.165	3818.10	142.513	4417.91	0.76	45.62	165.76	391.72	111.65	53.11	1.37
		Jun-00	0.284	4.64	123.077	3815.39	126.807	3931.01	1.37	83.19	139.80	334.23	19.31	475.35	12.19
		Jul-00	0.303	5.18	123.188	3818.84	161.192	4996.95	7.42	453.14	131.78	316.85	9.71	-50.58	-1.18
		Aug-00	0.295	5.24	123.146	3817.52	149.083	4621.57	2.30	140.08	129.00	309.33	-10.96	-9.56	-0.24
		Sep-00	0.307	5.68	123.250	3820.75	173.885	5390.42	7.08	432.84	112.51	270.80	47.30	-582.83	-12.44
		Oct-00	0.317	6.02	123.249	3820.72	174.821	5419.45	10.82	662.91	108.45	261.59	-3.68	-1193.74	-26.62
		Nov-00	0.314	5.33	123.269	3821.34	133.831	4148.76	0.80	48.99	93.83	226.24	16.54	-521.20	-13.47
		Dec-00	0.314	4.81	123.072	3815.23	109.085	3381.63	0.22	13.47	80.53	194.16	-3.67	256.58	6.70
6	3	Apr-00	0.000	--	0.000	0.00	6.778	210.11	4.90	284.00	142.60	325.39	0.00	-250.33	-90.70
		May-00	0.092	3.49	54.604	1692.72	16.197	502.12	0.76	44.68	165.76	383.67	757.15	257.61	14.83
		Jun-00	0.371	10.06	221.248	6858.68	262.041	8123.26	1.37	85.78	139.80	344.63	172.07	264.48	3.81
		Jul-00	0.433	10.42	258.041	7999.26	348.906	10816.10	7.42	471.76	131.78	329.86	257.88	-465.11	-5.49
		Aug-00	0.569	9.82	257.948	7996.38	327.421	10150.04	2.30	151.61	129.00	334.79	74.36	-131.68	-1.62
		Sep-00	0.413	4.67	103.167	3198.17	163.236	5060.33	7.08	459.07	112.51	287.21	-1297.05	1079.04	26.35
		Oct-00	0.018	--	0.000	0.00	26.772	829.94	10.82	632.63	108.45	249.64	0.00	-460.98	-75.64
		Nov-00	-0.008	--	0.000	0.00	0.000	0.00	0.80	46.36	93.83	214.06	16.90	-179.91	-399.26
		Dec-00	-0.007	--	0.000	0.00	0.000	0.00	0.22	12.69	80.53	182.83	0.00	-166.19	-1341.12

## Exhibit B-2

Monthly Averages of Field Measurements Collected from the ENR South Head Cell and the PSTA Test Cells, April - December 2000

Parameter	Month	Head Cell	Treatment		
			4 (Peat- Ca amended)	5 (Shellrock)	6 (Shellrock - Variable Stage)
Water Temp (°C)	Apr-00	24.68	26.09	25.21	21.74
	May-00	27.19	28.46	27.23	26.12
	Jun-00	28.57	29.87	28.91	30.24
	Jul-00	28.97	29.38	28.91	30.88
	Aug-00	28.87	28.21	28.13	29.70
	Sep-00	28.09	26.92	28.52	28.15
	Oct-00	24.61	24.59	23.84	--
	Nov-00	21.93	20.44	20.00	--
	Dec-00	19.74	21.02	19.39	--
pH (units)	Apr-00	7.56	7.85	8.01	7.26
	May-00	7.42	7.73	7.86	7.63
	Jun-00	7.39	8.67	7.85	7.79
	Jul-00	7.27	8.49	7.78	7.76
	Aug-00	7.29	7.64	7.28	7.69
	Sep-00	7.13	7.21	7.13	7.72
	Oct-00	7.61	7.22	7.08	--
	Nov-00	--	7.26	7.21	--
	Dec-00	7.24	7.10	7.20	--
Conductivity (µmhos/cm)	Apr-00	1020	1117	980	775
	May-00	1152	1184	1167	1176
	Jun-00	1136	1011	1056	1162
	Jul-00	1100	974	1021	1013
	Aug-00	1246	1083	1201	1222
	Sep-00	1210	1086	1236	1083
	Oct-00	939	1055	993	--
	Nov-00	--	1086	1082	--
	Dec-00	1168	1139	1141	--
Total Dissolved Solids (g/L)	Apr-00	0.652	0.715	0.627	0.496
	May-00	0.737	0.758	0.747	0.752
	Jun-00	0.727	0.647	0.676	0.744
	Jul-00	0.704	0.623	0.653	0.648
	Aug-00	0.796	0.693	0.769	0.782
	Sep-00	0.772	0.695	0.791	0.693
	Oct-00	0.680	0.670	0.640	--
	Nov-00	0.700	0.700	0.700	--
	Dec-00	0.750	0.740	0.720	--
Dissolved Oxygen Saturation (%)	Apr-00	62.6	22.2	110.1	6.3
	May-00	40.4	29.5	111.0	63.1
	Jun-00	13.5	119.3	91.7	107.3
	Jul-00	5.9	111.8	75.0	120.0
	Aug-00	7.3	45.8	40.7	122.8
	Sep-00	2.9	6.1	29.0	111.5
	Oct-00	16.8	16.7	7.8	--
	Nov-00	15.9	5.6	6.5	--
	Dec-00	28.7	29.3	10.7	--
Dissolved Oxygen (mg/L)	Apr-00	5.14	1.69	8.89	0.55
	May-00	3.21	2.15	8.56	5.07
	Jun-00	1.04	9.77	6.91	7.97
	Jul-00	0.46	9.23	5.66	8.86
	Aug-00	0.56	3.48	3.11	9.25
	Sep-00	0.23	0.48	2.13	8.63
	Oct-00	1.41	1.35	0.65	--
	Nov-00	1.43	0.55	0.83	--
	Dec-00	2.63	1.80	1.30	--

**Exhibit B-3**

Monthly Averages of Water Quality Data Collected at the ENR South Head Cell and PSTA Test Cells, April - December 2000

Parameter	Month	Treatment					
		4 (Peat- Ca amended)		5 (Shellrock)		6 (Shellrock-Variable Stage)	
		Inflow <sup>a</sup>	Outflow	Inflow <sup>a</sup>	Outflow	Inflow <sup>a</sup>	Outflow
Total Phosphorus as P (µg/L)	Apr-00	19.0	102.0	20.5	12.3	--	--
	May-00	17.6	88.6	18.8	11.4	17.5	22.0
	Jun-00	41.5	26.7	41.5	18.3	41.5	21.0
	Jul-00	31.0	13.1	30.8	10.1	30.8	14.6
	Aug-00	21.8	13.3	21.0	10.3	21.0	10.3
	Sep-00	24.0	20.4	23.8	14.6	24.3	11.8
	Oct-00	18.0	13.5	18.0	12.0	--	--
	Nov-00	20.6	18.1	20.2	9.5	--	--
	Dec-00	17.5	18.4	18.3	10.5	--	--
Total Particulate Phosphorus (µg/L)	Apr-00	5.0	64.0	5.6	2.5	--	--
	May-00	5.4	43.8	6.6	3.4	4.5	17.0
	Jun-00	22.5	9.7	22.5	7.3	22.5	7.7
	Jul-00	20.0	2.4	19.8	3.6	20.3	5.1
	Aug-00	8.5	6.0	6.8	4.8	8.0	3.5
	Sep-00	13.0	9.9	13.0	6.8	13.8	3.9
	Oct-00	7.4	5.0	7.4	5.5	--	--
	Nov-00	10.8	9.1	10.4	3.2	--	--
	Dec-00	7.3	8.0	8.0	3.5	--	--
Total Dissolved Phosphorus (µg/L)	Apr-00	14.0	38.0	14.9	9.8	--	--
	May-00	12.2	44.8	12.2	8.0	13.0	5.0
	Jun-00	19.0	17.0	19.0	11.0	19.0	13.3
	Jul-00	12.2	11.6	12.2	6.8	11.8	10.2
	Aug-00	24.0	7.3	25.0	5.5	23.8	6.8
	Sep-00	11.0	10.5	10.8	7.9	10.5	7.9
	Oct-00	10.6	8.5	10.6	6.5	--	--
	Nov-00	9.8	9.0	9.8	6.3	--	--
	Dec-00	10.3	10.4	10.3	7.0	--	--
Dissolved Reactive Phosphorus <sup>b</sup> (µg/L)	Apr-00	4.7	--	4.0	--	--	--
	May-00	3.8	5.1	3.2	--	3.9	--
	Jun-00	--	--	--	--	--	--
	Jul-00	--	--	--	--	--	--
	Aug-00	23.0	1.0	22.3	2.0	22.0	1.0
	Sep-00	7.5	1.0	7.3	2.0	7.0	1.0
	Oct-00	3.0	1.4	3.0	2.2	--	--
	Nov-00	2.4	1.4	2.4	1.3	--	--
	Dec-00	4.0	1.0	5.0	1.0	--	--
Dissolved Organic Phosphorus (µg/L)	Apr-00	9.4	--	10.9	--	--	--
	May-00	8.4	25.9	9.0	--	9.2	--
	Jun-00	--	--	--	--	--	--
	Jul-00	--	--	--	--	--	--
	Aug-00	2.5	7.0	4.3	5.0	3.3	7.0
	Sep-00	5.2	11.0	5.0	6.5	5.0	5.5
	Oct-00	7.6	6.9	7.6	4.2	--	--
	Nov-00	7.1	7.3	7.1	4.8	--	--
	Dec-00	9.0	9.5	8.0	6.0	--	--

**Exhibit B-3**

Monthly Averages of Water Quality Data Collected at the ENR South Head Cell and PSTA Test Cells, April - December 2000

Parameter	Month	Treatment					
		4 (Peat- Ca amended)		5 (Shellrock)		6 (Shellrock-Variable Stage)	
		Inflow <sup>a</sup>	Outflow	Inflow <sup>a</sup>	Outflow	Inflow <sup>a</sup>	Outflow
Total Nitrogen, as N (mg/L)	Apr-00	1.60	3.46	1.60	1.94	--	--
	May-00	2.21	2.96	2.21	2.58	2.21	--
	Jun-00	3.55	3.28	3.48	3.22	3.61	3.12
	Jul-00	2.10	2.05	2.10	2.40	2.10	1.91
	Aug-00	2.41	2.26	2.41	2.58	2.41	2.36
	Sep-00	2.34	2.25	2.30	1.89	2.51	2.17
	Oct-00	2.34	2.10	2.34	2.18	--	--
	Nov-00	2.54	2.28	2.54	2.08	--	--
	Dec-00	2.44	1.92	2.39	2.17	--	--
Total Kjeldahl Nitrogen, as N (mg/L)	Apr-00	1.58	3.46	1.58	1.94	--	--
	May-00	2.19	3.01	2.19	2.58	2.19	--
	Jun-00	3.52	3.32	3.45	3.22	3.57	3.12
	Jul-00	2.08	2.05	2.08	2.40	2.08	1.91
	Aug-00	2.41	2.24	2.41	2.58	2.41	2.36
	Sep-00	2.33	2.25	2.29	1.89	2.49	2.17
	Oct-00	2.29	2.10	2.29	2.18	--	--
	Nov-00	2.42	2.28	2.42	2.08	--	--
	Dec-00	2.27	1.92	2.23	2.17	--	--
Nitrate/Nitrite, as N (mg/L)	Apr-00	0.018	0.002	0.018	0.002	--	--
	May-00	0.019	0.002	0.019	0.002	0.019	--
	Jun-00	0.029	0.002	0.026	0.002	0.038	0.002
	Jul-00	0.022	0.002	0.022	0.002	0.022	0.002
	Aug-00	0.002	0.019	0.002	0.002	0.002	0.002
	Sep-00	0.007	0.002	0.009	0.002	0.016	0.002
	Oct-00	0.053	0.002	0.053	0.004	--	--
	Nov-00	0.125	0.002	0.125	0.002	--	--
	Dec-00	0.167	0.002	0.164	0.002	--	--
Ammonia, as NH <sub>3</sub> (mg/L)	Apr-00	0.020	0.113	0.020	0.017	--	--
	May-00	0.034	0.039	0.034	0.045	0.034	--
	Jun-00	0.168	0.005	0.174	0.002	0.174	0.007
	Jul-00	0.052	--	0.052	--	0.052	--
	Aug-00	0.040	--	0.040	--	0.040	--
	Sep-00	0.112	--	0.112	--	0.112	--
	Oct-00	--	--	--	--	--	--
	Nov-00	0.064	0.002	0.064	0.003	--	--
	Dec-00	0.107	0.002	0.098	0.002	--	--
Organic Nitrogen (mg/L)	Apr-00	1.56	3.35	1.56	1.92	--	--
	May-00	2.16	2.92	2.16	2.54	2.16	--
	Jun-00	3.35	3.28	3.28	3.22	3.40	3.11
	Jul-00	2.03	--	2.03	--	2.03	--
	Aug-00	2.37	--	2.37	--	2.37	--
	Sep-00	2.22	--	2.18	--	2.38	--
	Oct-00	--	--	--	--	--	--
	Nov-00	2.36	2.28	2.36	2.08	--	--
	Dec-00	2.16	1.92	2.13	2.16	--	--

**Exhibit B-3**

Monthly Averages of Water Quality Data Collected at the ENR South Head Cell and PSTA Test Cells, April - December 2000

Parameter	Month	Treatment					
		4 (Peat- Ca amended)		5 (Shellrock)		6 (Shellrock-Variable Stage)	
		Inflow <sup>a</sup>	Outflow	Inflow <sup>a</sup>	Outflow	Inflow <sup>a</sup>	Outflow
TOC (mg/L)	Apr-00	44.0	54.0	38.6	41.0	--	--
	May-00	43.0	55.0	43.0	48.0	43.0	--
	Jun-00	45.0	42.0	46.0	45.0	45.0	44.0
	Jul-00	33.0	34.0	33.0	38.0	33.0	35.0
	Aug-00	42.0	44.0	42.0	43.5	42.0	42.0
	Sep-00	48.0	41.0	47.0	39.5	47.0	42.0
	Oct-00	36.0	35.0	36.0	37.0	--	--
	Nov-00	37.0	35.5	37.0	34.0	--	--
	Dec-00	39.0	41.0	39.0	40.5	--	--
TSS <sup>c</sup> (mg/L)	Apr-00	1.0	9.3	2.3	1.4	--	--
	May-00	3.0	4.0	3.0	7.0	3.0	--
	Jun-00	2.0	3.0	1.0	2.0	1.0	1.0
	Jul-00	1.0	2.0	1.0	4.0	1.0	1.0
	Aug-00	2.0	6.0	2.0	5.5	2.0	2.0
	Sep-00	--	--	--	--	--	--
	Oct-00	1.0	1.5	1.0	1.0	--	--
	Nov-00	13.0	6.5	13.0	8.0	--	--
	Dec-00	1.0	1.0	1.0	2.5	--	--
Calcium (mg/L)	Apr-00	70.6	58.0	68.8	44.0	--	--
	May-00	62.6	51.9	62.6	44.8	62.6	--
	Jun-00	48.6	18.0	52.3	43.3	50.2	48.7
	Jul-00	70.6	22.8	70.6	48.8	70.6	64.2
	Aug-00	87.7	35.4	87.7	65.1	87.7	80.2
	Sep-00	74.7	33.7	74.7	57.4	74.7	59.8
	Oct-00	83.1	55.6	83.1	75.5	--	--
	Nov-00	81.4	63.2	81.4	68.1	--	--
	Dec-00	80.1	57.5	81.0	65.0	--	--
Alkalinity <sup>c</sup> (mg/L)	Apr-00	248	220	244	180	--	--
	May-00	230	204	230	192	230	--
	Jun-00	224	112	220	204	224	228
	Jul-00	232	100	232	180	232	220
	Aug-00	296	158	296	246	296	274
	Sep-00	--	--	--	--	--	--
	Oct-00	258	197	258	242	--	--
	Nov-00	288	278	288	248	--	--
	Dec-00	304	278	304	280	--	--

Notes:

One-half the method detection limit used in the calculation of monthly averages for undetected values.

<sup>a</sup>Inflow averages include data from constant head cell outlet and samples collected from individual cell inlets.

<sup>b</sup>DRP data are not available for June and July 2000 because of laboratory and holding time issues.

<sup>c</sup>TSS and alkalinity data are not available for September 2000 because of laboratory error.

**Exhibit B-4**

Monthly Summaries Total Phosphorus Mass Balance Data from the ENR Test Cells, April - December 2000

Treatment	Cell	Date	TP (mg/L)		Inflow (m <sup>3</sup> /d)	Outflow (m <sup>3</sup> /d)	Avg_flow (m <sup>3</sup> /d)	q_in (cm/d)	MB_TP (g/m <sup>2</sup> /y)		Removal		Calc_k (m/y)
			Inflow	Outflow					Inflow	Outflow	(g/m <sup>2</sup> /y)	(%)	
<b>Monthly</b> 4	13	Apr-00	19.0	102.0	121.98	65.61	93.79	5.18	0.359	1.037	-0.678	-188.76	-24.42
		May-00	17.6	88.6	121.90	112.22	117.06	5.15	0.331	1.431	-1.100	-332.59	-29.17
		Jun-00	41.5	26.7	121.78	96.67	109.22	5.11	0.772	0.392	0.380	49.25	7.39
		Jul-00	31.0	13.1	121.91	92.52	107.22	5.11	0.578	0.173	0.405	70.11	14.09
		Aug-00	21.8	13.3	121.90	104.98	117.67	5.10	0.405	0.231	0.173	42.88	8.90
		Sep-00	24.0	20.4	122.00	101.89	111.94	5.15	0.453	0.323	0.131	28.80	2.82
		Oct-00	18.0	13.5	121.94	143.64	132.79	5.05	0.331	0.294	0.037	11.19	5.77
		Nov-00	20.6	18.1	122.03	114.89	118.46	5.09	0.382	0.315	0.067	17.60	2.33
		Dec-00	17.5	18.4	121.78	91.72	106.75	5.10	0.326	0.255	0.071	21.71	-0.80
5	8	Apr-00	20.5	12.3	123.19	146.43	134.81	5.18	0.388	0.276	0.111	28.74	10.65
		May-00	18.8	11.4	123.16	139.48	131.32	5.21	0.357	0.247	0.110	30.81	10.14
		Jun-00	41.5	18.3	123.04	126.75	124.89	5.14	0.778	0.348	0.430	55.28	15.57
		Jul-00	30.8	10.1	123.17	157.91	140.54	5.12	0.575	0.249	0.325	56.60	23.70
		Aug-00	21.0	10.3	123.16	146.71	129.05	5.32	0.408	0.218	0.191	46.72	14.58
		Sep-00	23.8	14.6	123.26	175.26	149.26	5.21	0.454	0.388	0.066	14.52	11.14
		Oct-00	18.0	12.0	123.20	167.48	145.34	5.11	0.335	0.312	0.023	6.92	8.91
		Nov-00	20.2	9.5	123.29	133.83	128.56	5.11	0.377	0.193	0.184	48.75	14.68
		Dec-00	18.3	10.5	123.04	109.08	116.06	5.10	0.340	0.177	0.163	47.87	9.71
6	3	Apr-00	--	--	--	--	--	--	--	--	--	--	--
		May-00	17.5	22.0	120.91	68.71	94.81	5.03	0.321	0.453	-0.132	-41.01	-3.28
		Jun-00	41.5	21.0	257.72	311.87	284.80	10.41	1.573	0.973	0.600	38.17	28.59
		Jul-00	30.8	14.6	258.01	344.08	301.05	10.26	1.149	0.751	0.398	34.64	32.48
		Aug-00	21.0	10.3	257.97	318.23	273.05	9.93	0.762	0.414	0.348	45.67	27.53
		Sep-00	24.3	11.8	92.12	194.78	143.45	3.58	0.310	0.315	-0.005	-1.77	14.88
		Oct-00	--	--	--	--	--	--	--	--	--	--	--
		Nov-00	--	--	--	--	--	--	--	--	--	--	--
		Dec-00	--	--	--	--	--	--	--	--	--	--	--

**Exhibit B-5**

Period-of-Record, Quarterly, and Monthly Summaries of Total Nitrogen Mass Balance Data from the ENR Test Cells, April - December 2000

Treatment	Cell	Date	TN (mg/L)		Inflow (m <sup>3</sup> /d)	Outflow (m <sup>3</sup> /d)	Avg_flow (m <sup>3</sup> /d)	q_in (cm/d)	MB_TN (g/m <sup>2</sup> /y)		Removal		Calc_k (m/y)
			Inflow	Outflow					Inflow	Outflow	(g/m <sup>2</sup> /y)	(%)	
<b>Monthly</b>													
4	13	Apr-00	1.60	3.46	121.98	65.61	93.79	5.18	30.24	35.17	-4.93	-16.32	-11.21
		May-00	2.21	2.96	121.85	135.85	128.85	5.14	41.42	61.86	-20.44	-49.33	-5.79
		Jun-00	3.55	3.28	121.56	104.62	113.09	5.10	66.03	52.51	13.52	20.48	1.37
		Jul-00	2.10	2.05	121.94	64.04	92.99	5.11	39.15	20.07	19.08	48.74	0.34
		Aug-00	2.41	2.26	121.85	128.07	124.96	5.09	44.82	44.17	0.64	1.44	1.23
		Sep-00	2.34	2.25	122.23	138.45	130.34	5.03	43.00	46.83	-3.83	-8.91	0.77
		Oct-00	2.34	2.10	122.14	161.66	141.90	5.07	43.34	51.48	-8.14	-18.78	2.33
		Nov-00	2.54	2.28	121.87	114.69	118.28	5.09	47.21	39.88	7.33	15.53	1.95
		Dec-00	2.44	1.92	121.72	88.59	105.15	5.10	45.43	26.02	19.41	42.73	3.86
5	8	Apr-00	1.60	1.94	123.24	168.51	145.87	5.22	30.47	50.51	-20.04	-65.79	-4.34
		May-00	2.21	2.58	123.11	151.39	137.25	5.20	41.93	60.20	-18.27	-43.57	-3.27
		Jun-00	3.48	3.22	122.82	126.57	124.70	5.13	65.17	62.14	3.03	4.65	1.48
		Jul-00	2.10	2.40	123.20	168.51	145.85	5.12	39.25	61.36	-22.11	-56.32	-2.95
		Aug-00	2.41	2.58	123.11	142.03	132.57	5.50	48.35	59.59	-11.25	-23.26	-1.43
		Sep-00	2.30	1.89	123.49	183.97	153.73	5.11	42.86	52.47	-9.61	-22.42	4.55
		Oct-00	2.34	2.18	123.40	158.57	140.99	5.13	43.78	52.41	-8.63	-19.71	1.51
		Nov-00	2.54	2.08	123.13	142.03	132.58	5.10	47.28	44.66	2.62	5.54	4.00
		Dec-00	2.39	2.17	122.98	126.57	124.78	5.10	44.46	41.45	3.01	6.77	1.87
6	3	Apr-00	--	--	--	--	--	--	--	--	--	--	--
		May-00	2.21	--	120.89	0.00	60.45	5.09	41.07	--	--	--	--
		Jun-00	3.61	3.12	257.24	324.79	291.02	10.38	136.73	149.20	-12.47	-9.12	6.25
		Jul-00	2.10	1.91	258.06	379.91	318.99	10.33	79.21	106.06	-26.85	-33.89	4.42
		Aug-00	2.41	2.36	257.88	311.66	284.77	9.98	87.79	103.89	-16.11	-18.35	0.84
		Sep-00	2.51	2.17	0.00	85.61	42.81	0.00	0.00	27.71	-27.71	--	0.95
		Oct-00	--	--	--	--	--	--	--	--	--	--	--
		Nov-00	--	--	--	--	--	--	--	--	--	--	--
		Dec-00	--	--	--	--	--	--	--	--	--	--	--

**Exhibit B-6**

Monthly Summaries of Sediment Data from the ENR Test Cells, April - December 2000

Treatment <sup>a</sup>	Cell	Month	Density Wet (g/cm <sup>3</sup> )	Solids (%)	Bulk Den Dry (g/cm <sup>3</sup> )	TP (mg/kg)	TIP (mg/kg)	TKN (mg/kg)	TOC (mg/kg)
4	13	Apr-00	1.30	35.00	0.46	255.7	249.5	--	--
		May-00	0.64	44.20	0.28	226.7	215.1	--	--
		Jun-00	0.48	39.30	0.19	182.5	245.0	6800.0	145.5
		Jul-00	0.61	46.85	0.28	170.5	186.0	--	--
		Aug-00	0.64	38.90	0.25	413.0	159.5	--	--
		Sep-00	0.71	43.05	0.30	262.2	229.8	4745.0	190.0
		Oct-00	0.63	47.18	0.29	234.0	221.4	--	--
		Nov-00	--	--	--	--	--	--	--
		Dec-00	--	--	--	--	--	--	--
5	8	Apr-00	2.00	75.00	1.50	808.9	872.5	--	--
		May-00	1.42	66.10	0.95	805.8	798.6	--	--
		Jun-00	1.63	84.35	1.38	794.0	803.0	141.0	59.5
		Jul-00	1.65	81.40	1.34	710.0	861.5	--	--
		Aug-00	1.62	49.70	0.81	593.5	620.0	--	--
		Sep-00	1.80	73.98	1.33	811.9	786.6	141.5	43.5
		Oct-00	1.75	83.45	1.46	662.6	667.3	--	--
		Nov-00	--	--	--	--	--	--	--
		Dec-00	--	--	--	--	--	--	--
6	3	Apr-00	1.95	72.00	1.40	1023.3	1031.5	--	--
		May-00	1.76	78.80	1.39	912.5	943.1	--	--
		Jun-00	1.63	83.55	1.36	956.0	938.0	246.0	54.0
		Jul-00	1.73	83.20	1.44	814.0	845.5	--	--
		Aug-00	1.55	74.05	1.15	726.0	657.5	--	--
		Sep-00	1.71	74.30	1.27	953.6	915.2	131.5	49.0
		Oct-00	--	--	--	--	--	--	--
		Nov-00	1.60	84.40	1.35	892.8	844.9	--	--
		Dec-00	--	--	--	--	--	--	--

Notes:

No sediment samples collected from South ENR Test Cell Treatment Nos. 4 and 5 during November, December.  
 South ENR Test Cell Treatment No. 6 sediment collected during the month of November in place of October sampling.

**EXHIBIT B-7**

Non-Reactive Phosphorus Data Summary for PSTA Test Cell Sediments, April - December 2000

Treatment	Soil	Sampling Date	Moisture %	TP (mg/kg)	NaHCO <sub>3</sub> Pi (mg/kg)	NaHCO <sub>3</sub> TP (mg/kg)	Labile Po (mg/kg)	HClPi (mg/kg)	Alkali Hydrolyz Po (NaOH TP) (mg/kg)	Residual Po (mg/kg)
4	PE_limed	6/27/00	58.24	272.3	31.67	30.36	-1.31	199.4	-5.6	40.1
		9/19/00	61.17	237.6	17.16	24.25	7.09	150.3	-29.7	73.8
5	SR	6/27/00	19.00	824.6	3.50	4.28	0.77	742.0	-24.9	49.3
		9/19/00	20.01	752.8	3.16	2.87	-0.29	678.6	-14.3	43.4
6	SR	6/27/00	19.28	925.4	3.28	3.87	0.59	1075.2	-34.6	48.4
		9/19/00	19.91	979.4	2.58	3.62	1.03	990.0	-33.70	47.62

Notes:

Data from 6/00 represent composite samples collected from the 1/3 and 2/3 walkways within each Test Cell.

**Exhibit B-8**

Monthly Summaries of Algae and Macrophyte Percent Cover Estimates for the PSTA Test Cells, April - December 2000

Treatment <sup>a</sup>	Cell	Month	Blue-Green Algal Mat	Green Algal Mat	Emergent Macrophytes	Floating Aquatic Plants	Submerged Aquatic Plants	Algal Mat % Cover	Macrophyte % Cover	Total % Cover
4	13	Apr-00	0%	0%	1%	0%	0%	0%	1%	1%
		May-00	2%	0%	3%	0%	1%	2%	4%	6%
		Jun-00	1%	3%	5%	0%	54%	4%	59%	63%
		Jul-00	1%	0%	11%	0%	97%	1%	107%	108%
		Aug-00	3%	0%	14%	0%	100%	3%	114%	117%
		Sep-00	3%	0%	18%	0%	97%	3%	115%	118%
		Oct-00	18%	0%	38%	0%	97%	18%	135%	152%
		Nov-00	5%	1%	38%	0%	97%	6%	135%	140%
		Dec-00	3%	3%	31%	0%	97%	6%	128%	133%
5	8	Apr-00	11%	0%	18%	0%	69%	11%	87%	98%
		May-00	5%	0%	31%	0%	89%	5%	120%	125%
		Jun-00	8%	0%	14%	0%	53%	8%	67%	74%
		Jul-00	14%	0%	31%	0%	96%	14%	126%	141%
		Aug-00	6%	0%	48%	0%	97%	6%	145%	151%
		Sep-00	26%	0%	63%	0%	83%	26%	145%	171%
		Oct-00	18%	0%	63%	0%	83%	18%	145%	163%
		Nov-00	3%	6%	63%	0%	93%	9%	155%	164%
		Dec-00	1%	8%	38%	0%	97%	9%	135%	143%
6	3	Apr-00	0%	0%	31%	0%	0%	0%	31%	31%
		May-00	0%	0%	24%	0%	0%	0%	24%	25%
		Jun-00	0%	0%	39%	0%	8%	0%	47%	47%
		Jul-00	1%	0%	53%	0%	61%	1%	113%	114%
		Aug-00	2%	0%	46%	0%	68%	2%	113%	116%
		Sep-00	11%	0%	69%	0%	63%	11%	132%	143%
		Oct-00	--	--	--	--	--	--	--	--
		Nov-00	--	--	--	--	--	--	--	--
		Dec-00	0%	0%	18%	0%	0%	0%	18%	18%

## Exhibit B-9

Monthly Summaries of Periphyton Data from the ENR Test Cells, April - December 2000

Treatment	Cell	Month	Periphyton Biomass (g/m <sup>2</sup> )			Ca (g/m <sup>2</sup> )	Chl_a (corr) (mg/m <sup>2</sup> )	Pheo_a (mg/m <sup>2</sup> )	TP (g/m <sup>2</sup> )	TIP (g/m <sup>2</sup> )	TKN <sup>a</sup> (g/m <sup>2</sup> )	Blue-Green Algae		Diatoms		Green Algae		Other Taxa		Total Taxa		Biovolume (cm <sup>3</sup> /m <sup>2</sup> )	Evenness	SWDI
			Dry Wt	Ash Wt	AFDW							(# cells/m <sup>2</sup> ) * 10 <sup>6</sup>	(# taxa)	(# cells/m <sup>2</sup> ) * 10 <sup>6</sup>	(# taxa)	(# cells/m <sup>2</sup> ) * 10 <sup>6</sup>	(# taxa)	(# cells/m <sup>2</sup> ) * 10 <sup>6</sup>	(# taxa)	(# cells/m <sup>2</sup> ) * 10 <sup>6</sup>	(# taxa)			
4	13	Apr-00	3484.2	2354.9	1129.2	565.9	142.8	19.3	2.067	1.234	--	55945.8	9.0	5361.7	14.0	2077.4	8.0	0.0	0.0	63384.9	31.0	34.07	0.681	3.37
		May-00	821.2	607.1	214.0	216.5	177.6	7.6	0.525	0.176	--	297348.1	12.0	7057.8	7.5	9182.5	7.5	330.9	1.0	313753.9	27.5	47.87	0.704	3.36
		Jun-00	1399.2	961.0	438.2	355.0	396.5	113.4	0.800	0.436	10.97	94780.3	9.0	2256.0	6.0	3754.3	4.5	0.0	0.0	100790.6	19.5	14.40	0.638	2.73
		Jul-00	199.4	138.6	60.8	16.3	33.8	5.8	0.169	0.080	--	58927.9	14.5	48963.3	19.0	819.5	6.0	0.0	0.0	59890.1	23.0	1.93	0.633	2.86
		Aug-00	708.4	494.0	214.3	213.8	172.5	91.8	0.363	0.210	--	41722.7	7.5	1185.7	7.0	639.8	3.0	0.0	0.0	43548.3	17.5	15.09	0.562	2.33
		Sep-00	303.3	194.6	108.7	52.5	126.4	13.9	0.217	0.038	4.39	150799.2	14.0	194.1	1.0	944.1	3.0	0.0	0.0	151937.5	18.0	9.99	0.704	2.90
		Oct-00	555.0	763.7	209.5	200.6	391.1	60.3	0.504	0.074	--	--	--	--	--	--	--	--	--	--	--	--	--	
		Nov-00	805.0	1351.4	546.4	199.1	164.4	75.1	0.750	0.235	--	--	--	--	--	--	--	--	--	--	--	--	--	
		Dec-00	229.2	369.3	140.1	70.7	191.6	20.6	0.371	0.031	6.88	658750.5	12.0	0.0	0.0	1027.0	2.0	0.0	0.0	659777.4	14.0	110.92	0.802	3.06
5 <sup>b</sup>	8	Apr-00	578.8	427.8	151.0	124.9	172.5	0.0	0.365	0.043	--	431530.2	10.5	19515.1	7.5	1573.8	2.0	0.0	0.0	452619.1	20.0	22.57	0.702	3.03
		May-00	476.2	333.1	143.1	89.1	197.7	22.8	0.157	0.062	--	255802.2	13.0	12194.8	10.5	1439.2	2.5	0.0	0.0	269436.1	26.0	17.31	0.615	2.89
		Jun-00	238.9	164.7	74.2	65.6	152.5	1.3	0.076	0.044	2.34	132637.4	19.0	3415.4	10.5	2792.9	6.0	0.0	0.0	138845.6	35.5	27.46	0.716	3.68
		Jul-00	147.7	102.1	45.6	155.0	281.5	5.4	0.038	0.026	--	--	--	--	--	--	--	--	--	--	--	--	--	
		Aug-00	327.1	231.3	95.8	77.3	128.9	27.0	0.137	0.027	--	--	--	--	--	--	--	--	--	--	--	--	--	
		Sep-00	273.3	173.9	99.5	65.6	247.4	41.6	0.166	0.023	4.44	170662.2	15.0	988.2	6.0	816.6	5.0	0.0	0.0	172466.9	26.0	21.58	0.713	3.34
		Oct-00	248.1	369.0	120.9	95.0	242.4	35.1	0.193	0.045	--	--	--	--	--	--	--	--	--	--	--	--	--	
		Nov-00	809.9	1088.0	278.1	228.8	428.4	137.1	0.623	0.113	--	--	--	--	--	--	--	--	--	--	--	--	--	
		Dec-00	317.4	461.2	143.7	108.1	225.3	43.6	0.464	0.174	6.89	308881.7	13.0	6751.6	6.0	562.7	1.0	0.0	0.0	316426.2	20.0	56.71	0.748	3.24
6	3	Apr-00	328.1	220.0	108.1	57.2	63.6	0.0	0.242	0.012	--	525711.1	13.0	4023.1	4.5	5331.2	1.5	0.0	0.0	535065.4	19.0	10.44	0.770	3.27
		May-00	215.3	147.1	95.2	70.3	66.4	2.8	0.257	0.079	--	72117.0	10.5	2362.3	8.0	1806.5	4.0	0.0	0.0	76285.8	22.5	8.75	0.610	2.76
		Jun-00	407.5	301.6	106.0	202.2	115.7	16.4	0.731	0.459	5.47	111945.6	14.5	869.6	3.5	2010.1	3.5	0.0	0.0	114825.4	21.5	2.64	0.732	3.24
		Jul-00	195.9	144.5	51.5	124.9	142.0	5.6	0.244	0.103	--	294416.6	14.0	152162.4	14.5	3636.5	5.0	0.0	0.0	301189.0	24.0	15.16	0.619	2.84
		Aug-00	216.6	159.2	57.3	66.2	92.7	37.6	0.149	0.103	--	223010.4	12.5	1029.9	2.0	436.7	1.0	0.0	0.0	224477.1	15.5	6.08	0.773	3.06
		Sep-00	275.0	174.8	100.2	59.8	155.9	20.0	0.166	0.023	3.84	389149.9	15.0	3046.5	7.5	10529.5	7.0	0.0	0.0	402725.9	29.5	28.34	0.620	3.02
		Oct-00	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
		Nov-00	346.1	546.7	200.7	97.8	343.1	60.0	0.439	0.086	--	--	--	--	--	--	--	--	--	--	--	--	--	
		Dec-00	46.5	103.6	57.1	20.9	71.1	14.3	0.175	0.015	2.45	13650.5	13.0	1027.3	11.0	64.3	3.0	0.0	0.0	14742.1	27.0	1.91	0.659	3.14

**EXHIBIT B-10**

Non-Reactive Phosphorus Data Summary for PSTA Test Cell Periphyton, April - December 2000

Treatment	Soil	Sampling Date	Moisture %	TP mg/kg	NaHCO <sub>3</sub> Pi mg/kg	NaHCO <sub>3</sub> TP mg/kg	Labile Po mg/kg	HClPi mg/kg	Alkali Hydrolyz Po (NaOH TP) mg/kg	Residual Po mg/kg
4	PE_limed	6/27/00	--	--	--	--	--	--	--	--
		9/20/00	94.3	447.6	5.19	227.03	221.83	132.1	46.6	92.1
		12/18/00	94.4	645.0	11.28	430.4	419.1	94.4	77.4	47.9
5	SR	6/27/00	95.4	278.4	2.55	173.62	171.08	106.2	15.5	25.4
		9/20/00	93.4	230.6	2.13	133.93	131.80	37.4	29.6	36.7
		12/18/00	92.6	227.6	5.26	171.4	166.2	32.6	10.1	21.5
6	SR	6/27/00	85.0	511.2	1.72	129.63	127.90	306.3	23.7	95.5
		9/20/00	95.3	528.8	2.18	256.09	253.91	304.9	37.2	112.4
		12/18/00	60.7	474.8	3.47	183.1	179.7	254.0	31.5	103.3

Notes:

Data from 6/00 represent composite samples collected from the 1/3 and 2/3 walkways within each Test Cell.

Data from 9/00 represent samples collected from 2/3 walkway within each Test Cell.

## EXHIBIT B-11

ENR PSTA Test Cell Average Algal Cell Counts (# cells/m<sup>2</sup> x 10<sup>6</sup>), April - December 2000

Organism Code	Division Code	Organism	Treatment		
			4	5	6
APH DEL	1	APHANOCAPSA DELICATISSIMA	6,785	1,767	4,869
APH INC	1	APHANOCAPSA INCERTA	--	--	1,830
APH NUB	1	APHANOCAPSA NUBILUM	5,971	--	--
APH PLA	1	APHANOCAPSA PLANCTONICA?	493	--	827
APHA CLA	1	APHANOTHECE CLATHRATA	380	131	188
APHA MIC	1	APHANOTHECE MICROSCOPICA	147	--	--
APHA SMI	1	APHANOTHECE SMITHII	7,223	1,513	7,909
APHA STA	1	APHANOTHECE STAGNINA	276	2,235	15,674
APHA VAR	1	APHANOTHECE VARIABILIS?	--	251	--
APHN FLO	1	APHANIZOMENON FLOS-AQUAE	--	476	678
CAL EPI	1	CALOTHRIX EPIPHYTICA	132	--	--
CHR DIS	1	CHROOCOCCUS DISPERSUS	460	281	4,237
CHR MIN	1	CHROOCOCCUS MINUTUS	211	759	2,037
CHR MINI	1	CHROOCOCCUS MINIMUS	3,131	3,548	14,158
CHR TUR	1	CHROOCOCCUS TURGIDUS	--	--	33
COE KUE	1	COELOSPHAERIUM KUETZINGIANUM	128	--	--
CYL STA	1	CYLINDROSPERMUM STAGNALE	462	--	--
G ANA	1	ANABAENA SP	182	--	3,358
G CYL	1	CYLINDROSPERMUM SP	902	5,667	9,024
G GLO	1	GLOEOPCAPSA SP	54	2,979	815
G LYN SM	1	LYNGBYA SP (SMALL)	13,582	--	4,811
G OSC ME	1	OSCILLATORIA SP (MEDIUM)	1,027	--	--
G OSC SM	1	OSCILLATORIA SP (SMALL)	2,497	3,474	876
G SCY	1	SCYTONEEMA SP?	11,533	3,862	903
G SYNE	1	SYNECHOCOCCUS SP	15	9,221	18,445
GOM APO	1	GOMPHOSPHAERIA APONINA	--	--	340
JOH PEL	1	JOHANNESBAPTISTIA PELLUCIDA	--	--	2,226
LYN AER	1	LYNGBYA AERUGINEO-CARULEA?	134	1,327	3,559
LYN EPI	1	LYNGBYA EPIPHYTICA	6,063	3,808	13,190
LYN LAG	1	LYNGBYA LAGERHEIMII	27,095	17,927	22,260
LYN LIM	1	LYNGBYA LIMNETICA	11,791	32,703	62,508
LYN PER	1	LYNGBYA PERELEGANS?	--	--	9
MER GLA	1	MERISMOPEDIA GLAUCA	46	84	--
MER PUN	1	MERISMOPEDIA PUNCTATA	128	--	--
MER TEN	1	MERISMOPEDIA TENUISSIMA	1,323	21	1,093
MIC AER	1	MICROCYSTIS AERUGINOSA	92	--	--
MIC FIR	1	MICROCYSTIS FIRMA	1,562	990	1,486
OSC AMP	1	OSCILLATORIA AMPHIBIA	53	1,336	535
OSC ANG	1	OSCILLATORIA ANGUSTISSIMA	26,001	27,435	33,918
OSC FOR	1	OSCILLATORIA FORMOSA	3,652	11,608	1,462
OSC LIM	1	OSCILLATORIA LIMNETICA	9,329	20,159	10,585
OSC TEN	1	OSCILLATORIA TENUIS	304	--	--
OSC WIL	1	OSCILLATORIA WILLEI?	--	2,673	--
PHO TEN	1	PHORMIDIUM TENUE	--	327	--
RHA LIN	1	RHABDODERMA LINEARE?	--	450	--
SCH ARE	1	SCHIZOTHRIX ARENARIA?	3,759	5,807	892
SPI LAX	1	SPIRULINA LAXA	62	8	--
SPI SUB	1	SPIRULINA SUBSALSA	4	756	64
ANK FAL	3	ANKISTRODESMUS FALCATUS	47	--	--
ANK NAN	3	ANKISTRODESMUS NANNOSELENE	72	--	--
ANK SPI	3	ANKISTRODESMUS SPIRALIS	185	17	95
CHA ENS	3	CHARACIUM ENSIFORME	24	--	--
COE MIC	3	COELASTRUM MICROPORUM	--	--	30

## EXHIBIT B-11

ENR PSTA Test Cell Average Algal Cell Counts (# cells/m<sup>2</sup> x 10<sup>6</sup>), April - December 2000

Organism Code	Division Code	Organism	Treatment		
			4	5	6
COE SPH	3	COELASTRUM SPHAERICUM	26	21	--
COS ANG CO	3	COSMARIUM ANGULOSUM V CONCINNUM	37	--	--
COS BOT	3	COSMARIUM BOTRYTIS	3	--	--
COS GRAN	3	COSMARIUM GRANATUM	15	--	--
COS SUBR	3	COSMARIUM SUBRENIFORME	94	80	2
COS TUB	3	COSMOCLADIUM TUBURCULATUM	--	16	--
CRU API	3	CRUCIGENIA APICULATA	--	--	61
EUA COR ME	3	EUASTRUM CORNUBIENSE V MEDIANUM	--	9	--
G CHLA	3	CHLAMYDOMONAS SP	--	--	34
G COS	3	COSMARIUM SP	--	8	--
G MOU	3	MOUGEOTIA SP	--	162	105
G OED	3	OEDOGONIUM SP	80	5	--
G SPI	3	SPIROGYRA SP	18	5	--
G STAU	3	STAURASTRUM SP	23	--	--
GOL RAD	3	GOLENKNIA RADIATA	15	--	--
KIR LUN	3	KIRCHNERIELLA LUNARIS	23	--	--
KIR OBE	3	KIRCHNERIELLA OBESA	47	--	31
OED PUN	3	OEDOGONIUM PUNCTATOSTRIATUM	--	158	--
OOC PAR	3	OOCYSTIS PARVA	203	107	45
OOC SOL	3	OOCYSTIS SOLITARIA	65	--	144
PED BIR	3	PEDIASTRUM BIRADIATUM	189	--	--
PED TET TE	3	PEDIASTRUM TETRAS V TETRAODON	73	--	120
SCE ACU	3	SCENEDESMUS ACUMINATUS	187	--	--
SCE ARM	3	SCENEDESMUS ARMATUS	--	--	135
SCE BIJ	3	SCENEDESMUS BIJUGA	552	104	453
SCE BIJ AL	3	SCENEDESMUS BIJUGA V ALTERNANS	187	--	315
SCE DIM	3	SCENEDESMUS DIMORPHUS	--	--	47
SCE QUA	3	SCENEDESMUS QUADRICAUDA	132	--	165
SPH SCH	3	SPHAEROCYSTIS SCHROERTERI	28	75	1,163
SPO PLA	3	SPONDYLOSIMUM PLANUM	24	--	--
STAU TET	3	STAURASTRUM TETRACERUM	--	53	--
TET MIN	3	TETRAEDRON MINIMUM	25	--	154
TET TRI	3	TETRAEDRON TRIGONUM	64	102	114
UN FIL CH	3	UNID FILAMENTOUS CHLOROPHYTA	126	63	404
ACHN MIN	4	ACHNANTHIDIUM MINUTISSIMUM	15	47	126
AMP OVA AF	4	AMPHORA OVALIS V AFFINIS	--	--	5
CO COC PLA LI	4	COCCONEIS PLACENTULA V LINEATA	--	--	30
CYM MIC	4	CYMBELLA MICROCEPHALA	15	347	86
DIP OBL	4	DIPLONEIS OBLONGELLA	--	45	6
DIP OVA	4	DIPLONEIS OVALIS	123	--	36
ENC EVE	4	ENCYONEMA EVERGLADIANUM	117	1,311	220
ENC SIL EL	4	ENCYONEMA SILESIACUM V ELEGANS	93	229	44
EPI ADN	4	EPITHEMIA ADNATA	187	47	68
FRA FAS	4	FRAGILARIA FASCICULATA?	--	180	125
FRA NAN	4	FRAGILARIA NANANA?	--	208	5
FRA SYN	4	FRAGILARIA SYNEGROTESCA	7	477	94
G AMP	4	AMPHORA SP	4	--	--
G NAV SM	4	NAVICULA SP (SMALL)	24	--	--
G NIT	4	NITZSCHIA SP	7	--	64
G NIT ME	4	NITZSCHIA SP (MEDIUM)	--	--	12
G NIT SM	4	NITZSCHIA SP (SMALL)	243	5	8
GOM INT VI	4	GOMPHONEMA INTRICATUM V VIBRIO	15	45	--
GOM PAR	4	GOMPHONEMA PARVULUM	4	--	43

## EXHIBIT B-11

ENR PSTA Test Cell Average Algal Cell Counts (# cells/m<sup>2</sup> x 10<sup>6</sup>), April - December 2000

Organism Code	Division Code	Organism	Treatment		
			4	5	6
MAS LANC	4	MASTOGLOIA LANCEOLATA	--	19	2
MAS SMI	4	MASTOGLOIA SMITHII	115	345	172
MAS SMI LA	4	MASTOGLOIA SMITHII V LACUSTRIS	38	690	60
NAV CRY	4	NAVICULA CRYPTOCEPHALA	290	--	69
NAV CRYP	4	NAVICULA CRYPTOTENELLA	249	72	195
NAV POD	4	NAVICULA PODZORSKII	4	--	--
NAV PUP RE	4	NAVICULA PUPULA V RECTANGULARIS	9	--	--
NAV RAD	4	NAVICULA RADIOSA	11	--	--
NIT AMP	4	NITZSCHIA AMPHIBIA	239	--	--
NIT CON	4	NITZSCHIA CONSTRICTA	9	--	--
NIT FRU	4	NITZSCHIA FRUSTULUM	37	--	--
NIT PAL	4	NITZSCHIA PALEA	47	--	5
NIT PALE	4	NITZSCHIA PALEACEA	51	119	--
NIT PALF	4	NITZSCHIA PALEAFORMIS	--	121	--
NIT SCA	4	NITZSCHIA SCALARIS	--	--	5
NIT SEM	4	NITZSCHIA SEMIROBUSTA	254	1,297	746
NIT SERP	4	NITZSCHIA SERPENTIRAPHE	7	28	32
RHO GIBA	4	RHOPALODIA GIBBA	96	10	--
G EUG	10	EUGLENA SP	24	--	--

## EXHIBIT B-12

ENR PSTA Test Cell Average Algal Biovolume Data (cm<sup>3</sup>/m<sup>2</sup>), April - December 2000

Organism Code	Division Code	Organism	ENR South Test Cell PSTA Treatment		
			4	5	6
APH DEL	1	APHANOCAPSA DELICATISSIMA	0.007	0.002	0.005
APH INC	1	APHANOCAPSA INCERTA	--	--	0.002
APH NUB	1	APHANOCAPSA NUBILUM	0.024	--	--
APH PLA	1	APHANOCAPSA PLANCTONICA?	0.004	--	0.007
APHA CLA	1	APHANOTHECE CLATHRATA	0.001	0.000	0.001
APHA MIC	1	APHANOTHECE MICROSCOPICA	0.004	--	--
APHA SMI	1	APHANOTHECE SMITHII	0.043	0.009	0.047
APHA STA	1	APHANOTHECE STAGNINA	0.007	0.054	0.376
APHA VAR	1	APHANOTHECE VARIABILIS?	--	0.002	--
APHN FLO	1	APHANIZOMENON FLOS-AQUAE	--	0.010	0.015
CAL EPI	1	CALOTHRIX EPIPHYTICA	0.005	--	--
CHR DIS	1	CHROOCOCCUS DISPERSUS	0.006	0.004	0.059
CHR MIN	1	CHROOCOCCUS MINUTUS	0.002	0.008	0.022
CHR MINI	1	CHROOCOCCUS MINIMUS	0.013	0.014	0.057
CHR TUR	1	CHROOCOCCUS TURGIDUS	--	--	0.009
COE KUE	1	COELOSPHAERIUM KUETZINGIANUM	0.001	--	--
CYL STA	1	CYLINDROSPERMUM STAGNALE	0.037	--	--
G ANA	1	ANABAENA SP	0.003	--	0.064
G CYL	1	CYLINDROSPERMUM SP	0.032	0.198	0.316
G GLO	1	GLOEOCAPSA SP	0.000	0.012	0.003
G LYN SM	1	LYNGBYA SP (SMALL)	0.068	--	0.024
G OSC ME	1	OSCILLATORIA SP (MEDIUM)	0.087	--	--
G OSC SM	1	OSCILLATORIA SP (SMALL)	0.012	0.017	0.004
G SCY	1	SCYTONEMA SP?	15.973	5.349	1.251
G SYNE	1	SYNECHOCOCCUS SP	0.001	0.590	1.180
GOM APO	1	GOMPHOSPHAERIA AAPONINA	--	--	0.010
JOH PEL	1	JOHANNESBAPTISTIA PELLUCIDA	--	--	0.125
LYN AER	1	LYNGBYA AERUGINEO-CARULEA?	0.016	0.157	0.420
LYN EPI	1	LYNGBYA EPIPHYTICA	0.036	0.023	0.079
LYN LAG	1	LYNGBYA LAGERHEIMII	0.163	0.108	0.134
LYN LIM	1	LYNGBYA LIMNETICA	0.295	0.818	1.563
LYN PER	1	LYNGBYA PERELEGANS?	--	--	0.000
MER GLA	1	MERISMOPEDIA GLAUDA	0.001	0.001	--
MER PUN	1	MERISMOPEDIA PUNCTATA	0.000	--	--
MER TEN	1	MERISMOPEDIA TENUISSIMA	0.001	0.000	0.001
MIC AER	1	MICROCYSTIS AERUGINOSA	0.003	--	--
MIC FIR	1	MICROCYSTIS FIRMA	0.012	0.008	0.012
OSC AMP	1	OSCILLATORIA AMPHIBIA	0.003	0.085	0.034
OSC ANG	1	OSCILLATORIA ANGUSTISSIMA	0.052	0.055	0.068
OSC FOR	1	OSCILLATORIA FORMOSA	0.288	0.917	0.115
OSC LIM	1	OSCILLATORIA LIMNETICA	0.065	0.141	0.074
OSC TEN	1	OSCILLATORIA TENUIS	0.018	--	--
OSC WIL	1	OSCILLATORIA WILLEI?	--	0.056	--
PHO TEN	1	PHORMIDIUM TENUE	--	0.008	--
RHA LIN	1	RHABDODERMA LINEARE?	--	0.020	--
SCH ARE	1	SCHIZOTHRIX ARENARIA?	0.049	0.075	0.012
SPI LAX	1	SPIRULINA LAXA	0.008	0.001	--
SPI SUB	1	SPIRULINA SUBSALSA	0.000	0.048	0.004
ANK FAL	3	ANKISTRODESMUS FALCATUS	0.002	--	--
ANK NAN	3	ANKISTRODESMUS NANNOSELENE	0.000	--	--
ANK SPI	3	ANKISTRODESMUS SPIRALIS	0.002	0.000	0.001
CHA ENS	3	CHARACIUM ENSIFORME	0.002	--	--
COE MIC	3	COELASTRUM MICROPORUM	--	--	0.002
COE SPH	3	COELASTRUM SPHAERICUM	0.002	0.002	--
COS ANG CO	3	COSMARIUM ANGULOSUM V CONCINNUM	0.030	--	--
COS BOT	3	COSMARIUM BOTRYTIS	0.088	--	--

## EXHIBIT B-12

ENR PSTA Test Cell Average Algal Biovolume Data ( $\text{cm}^3/\text{m}^2$ ), April - December 2000

Organism Code	Division Code	Organism	ENR South Test Cell PSTA Treatment		
			4	5	6
COS GRAN	3	COSMARIUM GRANATUM	0.185	--	--
COS SUBR	3	COSMARIUM SUBRENIFORME	0.025	0.021	0.000
COS TUB	3	COSMOCLADIUM TUBURCULATUM	--	0.002	--
CRU API	3	CRUCIGENIA APICULATA	--	--	0.002
EUA COR ME	3	EUASTRUM CORNUBIENSE V MEDIANUM	--	0.025	--
G CHLA	3	CHLAMYDOMONAS SP	--	--	0.009
G COS	3	COSMARIUM SP	--	0.021	--
G MOU	3	MOUGEOTIA SP	--	0.061	0.040
G OED	3	OEDOGONIUM SP	0.161	0.011	--
G SPI	3	SPIROGYRA SP	1.605	0.476	--
G STAU	3	STAURASTRUM SP	0.030	--	--
GOL RAD	3	GOLENKNIA RADIATA	0.002	--	--
KIR LUN	3	KIRCHNERIELLA LUNARIS	0.000	--	--
KIR OBE	3	KIRCHNERIELLA OBESA	0.000	--	0.000
OED PUN	3	OEDOGONIUM PUNCTATOSTRIATUM	--	1.270	--
OOC PAR	3	OOCYSTIS PARVA	0.005	0.003	0.001
OOC SOL	3	OOCYSTIS SOLITARIA	0.089	--	0.195
PED BIR	3	PEDIASTRUM BIRADIATUM	0.026	--	--
PED TET TE	3	PEDIASTRUM TETRAS V TETRAODON	0.006	--	0.010
SCE ACU	3	SCENEDESMUS ACUMINATUS	0.005	--	--
SCE ARM	3	SCENEDESMUS ARMATUS	--	--	0.009
SCE BIJ	3	SCENEDESMUS BIJUGA	0.006	0.001	0.005
SCE BIJ AL	3	SCENEDESMUS BIJUGA V ALTERNANS	0.006	--	0.010
SCE DIM	3	SCENEDESMUS DIMORPHUS	--	--	0.001
SCE QUA	3	SCENEDESMUS QUADRICAUDA	0.014	--	0.017
SPH SCH	3	SPHAEROCYSTIS SCHROERTERI	0.003	0.008	0.131
SPO PLA	3	SPONDYLOSIUM PLANUM	0.001	--	--
STAU TET	3	STAURASTRUM TETRACERUM	--	0.003	--
TET MIN	3	TETRAEDRON MINIMUM	0.001	--	0.007
TET TRI	3	TETRAEDRON TRIGONUM	0.062	0.099	0.111
UN FIL CH	3	UNID FILAMENTOUS CHLOROPHYTA	0.106	0.053	0.342
ACHN MIN	4	ACHNANTHIDIUM MINUTISSIMUM	0.002	0.007	0.018
AMP OVA AF	4	AMPHORA OVALIS V AFFINIS	--	--	0.008
COCC PLA LI	4	COCCONEIS PLACENTULA V LINEATA	--	--	0.036
CYM MIC	4	CYMBELLA MICROCEPHALA	0.003	0.059	0.015
DIP OBL	4	DIPLONEIS OBLONGELLA	--	0.015	0.002
DIP OVA	4	DIPLONEIS OVALIS	0.050	--	0.015
ENC EVE	4	ENCYONEMA EVERGLADIANUM	0.022	0.246	0.041
ENC SIL EL	4	ENCYONEMA SILESIACUM V ELEGANS	0.113	0.276	0.053
EPI ADN	4	EPITHEMIA ADNATA	1.571	0.394	0.572
FRA FAS	4	FRAGILARIA FASCICULATA?	--	0.332	0.232
FRA NAN	4	FRAGILARIA NANANA?	--	0.079	0.002
FRA SYN	4	FRAGILARIA SYNEGROTESCA	0.007	0.511	0.101
G AMP	4	AMPHORA SP	0.002	--	--
G NAV SM	4	NAVICULA SP (SMALL)	0.011	--	--
G NIT	4	NITZSCHIA SP	0.001	--	0.004
G NIT ME	4	NITZSCHIA SP (MEDIUM)	--	--	0.018
G NIT SM	4	NITZSCHIA SP (SMALL)	0.026	0.001	0.001
GOM INT VI	4	GOMPHONEMA INTRICATUM V VIBRIO	0.033	0.098	--
GOM PAR	4	GOMPHONEMA PARVULUM	0.008	--	0.077
MAS LANC	4	MASTOGLOIA LANCEOLATA	--	0.127	0.010
MAS SMI	4	MASTOGLOIA SMITHII	0.398	1.200	0.597
MAS SMI LA	4	MASTOGLOIA SMITHII V LACISTRIS	0.061	1.109	0.097
NAV CRY	4	NAVICULA CRYPTOCEPHALA	0.123	--	0.029
NAV CRYP	4	NAVICULA CRYPTOTENELLA	0.185	0.053	0.145
NAV POD	4	NAVICULA PODZORSKII	0.010	--	--

## EXHIBIT B-12

ENR PSTA Test Cell Average Algal Biovolume Data ( $\text{cm}^3/\text{m}^2$ ), April - December 2000

Organism Code	Division Code	Organism	ENR South Test Cell PSTA Treatment		
			4	5	6
NAV PUP RE	4	NAVICULA PUPULA V RECTANGULARIS	0.008	--	--
NAV RAD	4	NAVICULA RADIOSA	0.047	--	--
NIT AMP	4	NITZSCHIA AMPHIBIA	0.057	--	--
NIT CON	4	NITZSCHIA CONSTRICTA	0.005	--	--
NIT FRU	4	NITZSCHIA FRUSTULUM	0.008	--	--
NIT PAL	4	NITZSCHIA PALEA	0.025	--	0.002
NIT PALE	4	NITZSCHIA PALEACEA	0.003	0.007	--
NIT PALF	4	NITZSCHIA PALEAFORMIS	--	0.103	--
NIT SCA	4	NITZSCHIA SCALARIS	--	--	0.877
NIT SEM	4	NITZSCHIA SEMIROBUSTA	0.150	0.763	0.439
NIT SERP	4	NITZSCHIA SERPENTIRAPHE	0.064	0.262	0.294
RHO GIBA	4	RHOPALODIA GIBBA	2.442	0.265	--
G EUG	10	EUGLENA SP	0.304	--	--

**EXHIBIT B-13**Summary of Macrophyte Biomass Data (g dry/m<sup>2</sup>), April - December 2000

<b>Month</b>	<b>Treatment</b>		
	<b>4</b>	<b>5</b>	<b>6</b>
Apr-00	87	369	23
May-00	25	401	76
Jun-00	160	132	84
Jul-00	270	389	396
Aug-00	466	415	70
Sep-2000	632	612	56
Oct-2000	537	414	--
Nov-2000	551	525	93
Dec-2000	203	449	392
<b>Treatment Average</b>	<b>326</b>	<b>412</b>	<b>149</b>

**Exhibit B-14**

Monthly Summaries of PAR Extinction Measurements from the ENR Test Cells, April - December 2000

Treatment	Month	Water Depth (m)	PAR ( $\mu\text{mol/m}^2/\text{s}$ )		Z (m)	Ext Coeff ( $\text{m}^{-1}$ )
			Surface	Bottom		
4	Apr-00	0.24	1107.6	788.6	0.11	2.76
	May-00	--	--	--	--	--
	Jun-00	0.30	385.3	134.7	0.18	6.54
	Jul-00	0.29	451.3	145.9	0.17	8.35
	Aug-00	0.28	849.7	142.6	0.15	12.74
	Sep-00	0.36	502.4	22.4	0.23	14.00
	Oct-00	0.31	204.8	32.1	0.19	10.64
	Nov-00	0.30	1419.5	283.4	0.18	12.80
	Dec-00	0.29	1347.8	356.0	0.17	8.28
5	Apr-00	0.24	932.5	473.7	0.12	4.30
	May-00	0.24	1742.7	1446.8	0.12	1.73
	Jun-00	0.27	196.7	103.1	0.15	8.18
	Jul-00	0.29	473.2	165.6	0.17	6.75
	Aug-00	0.27	347.1	187.5	0.15	5.03
	Sep-00	0.32	315.6	18.5	0.19	19.45
	Oct-00	0.29	135.6	26.0	0.17	9.91
	Nov-00	0.30	368.4	33.3	0.17	17.09
	Dec-00	0.30	615.0	42.0	0.18	17.86
6	Apr-00	0.07	--	--	-0.05	--
	May-00	--	--	--	--	--
	Jun-00	0.43	190.5	91.1	0.31	2.42
	Jul-00	0.51	480.1	145.7	0.39	3.18
	Aug-00	0.56	1751.1	666.0	0.44	2.79
	Sep-00	0.38	789.6	290.0	0.26	3.65
	Oct-00	--	--	--	--	--
	Nov-00	--	--	--	--	--
	Dec-00	--	--	--	--	--

Notes:

Extinction coefficient =  $(\ln \text{PARsurf} - \ln \text{PARbot})/z$  and  $z$  = water depth - 0.122 m

PAR in Treatment 4 (Test Cell 13) influenced by macrophyte and submerged aquatic vegetation shading

**Exhibit B-15**

Monthly Summaries of Ecosystem Metabolism Data from the ENR Test Cells, April - December 2000

Treatment	Cell	Month	NPP(day) g/m <sup>2</sup> /d	GPP(day) g/m <sup>2</sup> /d	CR(24hr) g/m <sup>2</sup> /d	CM(24hr) g/m <sup>2</sup> /d	NPP(24hr) g/m <sup>2</sup> /d	Avg Night Res g/m <sup>2</sup> /hr	PAR(24hr) E/m <sup>2</sup> /d	Efficiency %
<b>Monthly</b> <b>4</b>	13	Apr-00	--	--	--	--	--	--	--	--
		May-00	0.266	0.957	1.078	0.957	-0.121	0.045	43.2	0.424
		Jun-00	2.987	8.770	8.674	8.770	0.096	0.361	35.0	4.794
		Jul-00	2.308	7.129	7.332	7.129	-0.203	0.306	33.4	4.090
		Aug-00	1.263	3.131	3.177	3.131	-0.046	0.132	28.3	2.117
		Sep-00	-0.076	0.275	0.580	0.275	-0.305	0.024	28.5	0.184
		Oct-00	0.090	0.526	0.727	0.526	-0.202	0.030	20.4	0.493
		Nov-00	-0.076	0.234	0.514	0.234	-0.281	0.021	23.5	0.190
		Dec-00	0.656	1.478	1.608	1.478	-0.130	0.067	18.5	1.533
<b>5</b>	8	Apr-00	--	--	--	--	--	--	--	--
		May-00	2.892	7.716	7.716	7.716	-0.002	0.322	44.9	3.289
		Jun-00	2.376	7.049	7.077	7.049	-0.028	0.295	36.1	3.737
		Jul-00	2.284	6.689	6.709	6.689	-0.020	0.280	23.2	5.527
		Aug-00	1.155	2.821	2.856	2.821	-0.035	0.119	32.1	1.681
		Sep-00	0.576	1.697	1.902	1.697	-0.205	0.079	28.1	1.154
		Oct-00	-0.211	0.142	0.324	0.142	-0.182	0.013	25.3	0.107
		Nov-00	-0.066	0.314	0.321	0.314	-0.006	0.013	20.5	0.293
		Dec-00	-0.316	0.012	0.302	0.012	-0.290	0.013	17.2	0.013
<b>6</b>	3	Apr-00	--	--	--	--	--	--	--	--
		May-00	--	--	--	--	--	--	--	--
		Jun-00	0.922	2.618	2.575	2.618	0.043	0.107	36.0	1.392
		Jul-00	1.902	5.318	5.197	5.318	0.121	0.217	36.3	2.805
		Aug-00	2.636	6.484	6.444	6.484	0.040	0.269	32.5	3.818
		Sep-00	1.959	4.468	4.399	4.468	0.068	0.183	23.2	3.679
		Oct-00	--	--	--	--	--	--	--	--
		Nov-00	--	--	--	--	--	--	--	--
		Dec-00	--	--	--	--	--	--	--	--

**Exhibit B-16**

South PSTA Test Cells Sediment Trap Data - Phase 2, April- September 2000

Site	Tank	Soil	Treatment	Date Installed	Date Collected	PSTA #	Sediment Volume (ml)	# Days	Wet Accretion (ml/m <sup>2</sup> /y)	Dry Accretion (g/m <sup>2</sup> /y)	TP Accretion (g/m <sup>2</sup> /y)	Wet Bulk Density (g/cm <sup>3</sup> )	Dry Bulk Density (g/cm <sup>3</sup> )	Wet Weight (g)	Dry Weight (g)	Moisture Content (%)	TP (mg/kg)	Ash (%)
STC	13-A	peat_limed	4	7/31/00	10/10/00	258	235	71	78448	15369	4.977	0.742	0.196	174.37	46.04	73.6	323.8	89.3
STC	13-B	peat_limed	4	7/31/00	10/10/00	259	230	71	76779	4338	3.147	0.607	0.056	139.67	12.99	90.7	725.4	77.0
STC	13-C	peat_limed	4	7/31/00	10/10/00	260	240	71	80117	15262	4.814	0.807	0.190	193.67	45.72	76.4	315.5	91.3
STC	13-D	peat_limed	4	7/31/00	10/10/00	261	140	71	46735	1086	0.772	0.420	0.023	58.78	3.25	94.5	711.6	70.9
STC	13-E	peat_limed	4	7/31/00	10/10/00	262	240	71	80117	1288	1.257	0.493	0.016	118.30	3.86	96.7	975.6	67.4
STC	13-F	peat_limed	4	7/31/00	10/10/00	263	240	71	80117	2858	2.367	0.520	0.036	124.88	8.56	93.1	828.2	70.7
STC	8-A	shell	5	7/31/00	10/10/00	252	510	71	170249	2012	1.614	0.342	0.012	174.27	6.03	96.5	802.3	54.1
STC	8-B	shell	5	7/31/00	10/10/00	253	470	71	156896	2502	1.919	0.404	0.016	190.07	7.49	96.1	767.1	53.3
STC	8-C	shell	5	7/31/00	10/10/00	254	160	71	53411	2283	1.632	0.607	0.043	97.13	6.84	93.0	714.7	75.7
STC	8-D	shell	5	7/31/00	10/10/00	255	470	71	156896	3974	2.097	0.465	0.025	218.57	11.90	94.6	527.8	65.1
STC	8-E	shell	5	7/31/00	10/10/00	256	200	71	66764	2798	2.694	0.567	0.042	113.41	8.38	92.6	962.8	77.3
STC	8-F	shell	5	7/31/00	10/10/00	257	640	71	213646	7290	8.139	0.544	0.034	348.47	21.84	93.7	1116.4	61.4
STC	3-A	shell	6	7/31/00	10/10/00	246	630	71	210307	1827	1.196	0.217	0.009	136.83	5.47	96.0	654.9	59.2
STC	3-B	shell	6	7/31/00	10/10/00	247	760	71	253704	2331	1.087	0.304	0.009	230.67	6.98	97.0	466.3	57.5
STC	3-C	shell	6	7/31/00	10/10/00	248	525	71	175256	1958	1.925	0.323	0.011	169.77	5.87	96.5	982.9	50.0
STC	3-D	shell	6	7/31/00	10/10/00	249	510	71	170249	1964	0.874	0.348	0.012	177.57	5.88	96.7	444.7	54.8
STC	3-E	shell	6	7/31/00	10/10/00	250	310	71	103485	2486	1.494	0.419	0.024	129.98	7.45	94.3	601.0	70.0
STC	3-F	shell	6	7/31/00	10/10/00	251	170	71	56750	1059	0.795	0.491	0.019	83.54	3.17	96.2	750.3	55.2

Note:

Sample Area = 154 cm<sup>2</sup> (14.0 cm diameter)

**APPENDIX C**

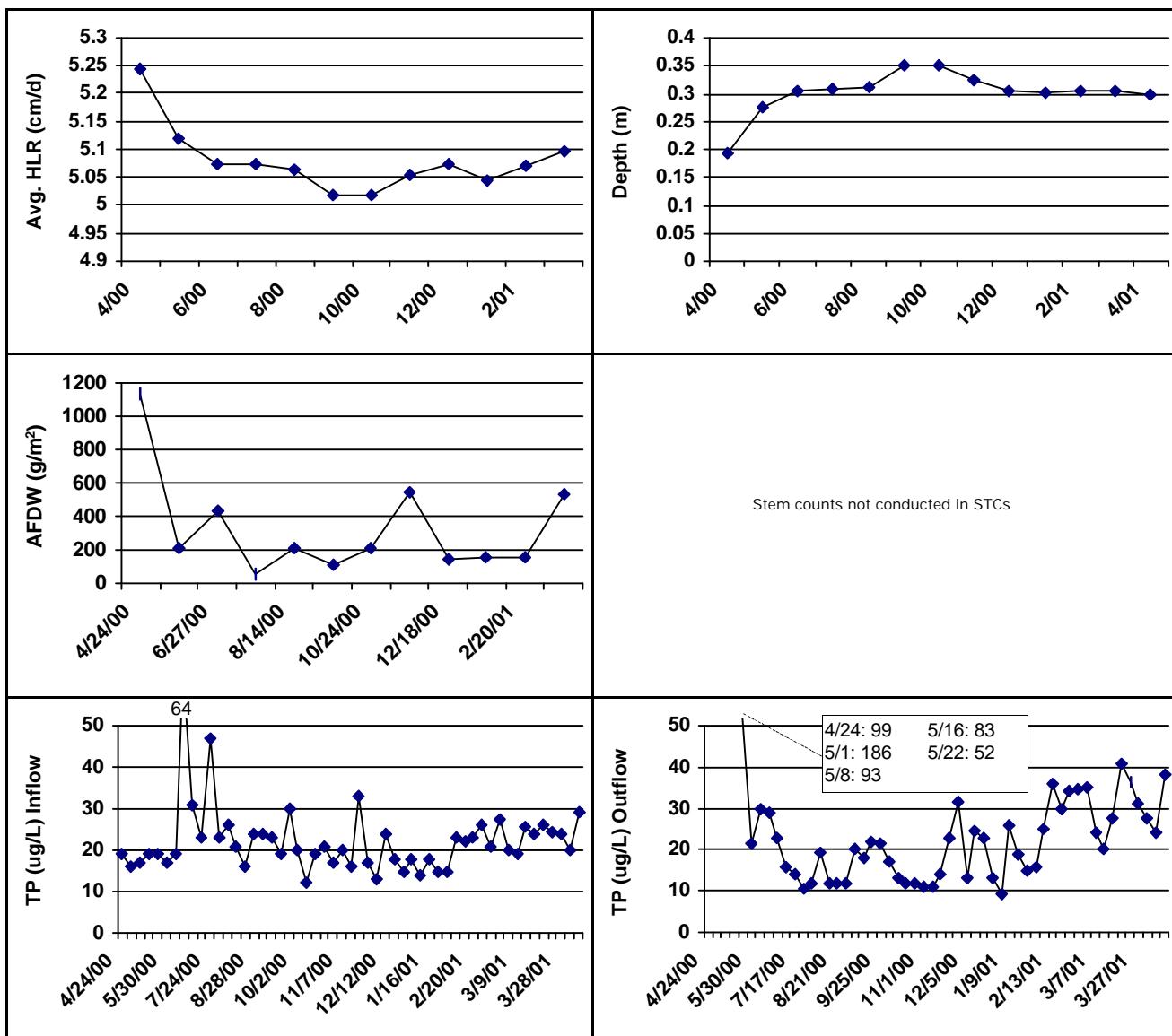
## **Data Trend Charts**

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# PSTA Research and Demonstration Project

Treatment:	STC-4	Period:	4/1/2000	-	4/30/2001
Tank(s)/Cell(s):	13	Plants:	yes	Other:	
Research Scale:	Test Cell	Recirculation:	no		
Mesocosm Size:	28 x 80 m (2240m <sup>2</sup> )	Soil:	peat amended with CaOH		

—♦— 13



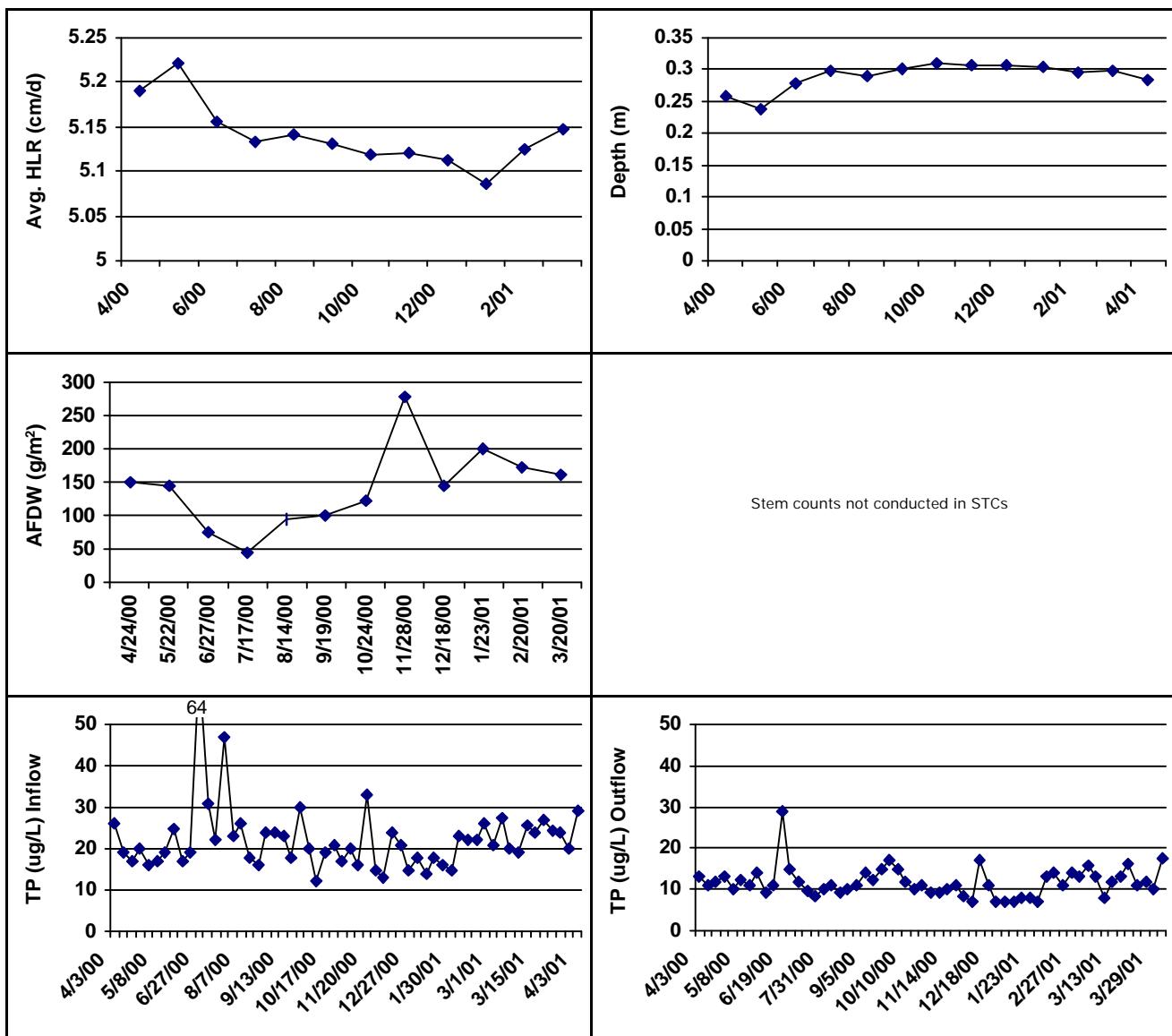
## Summary For Period

Tank/Cell	HLR (cm/d)	Depth (m)	TP in (ug/L)	TP out (ug/L)	k1 (m/y)
13	5.08	0.30	22	29	-5.0
Mean	5.08	0.30	22	29	-5.0

# PSTA Research and Demonstration Project

Treatment:	STC-5	Period:	4/1/2000	-	4/30/2001
Tank(s)/Cell(s):	8	Plants:	yes	Other:	
Research Scale:	Test Cell	Recirculation:	no		
Mesocosm Size:	28 x 80 m (2240m <sup>2</sup> )	Soil:	shellrock		

—♦— 8



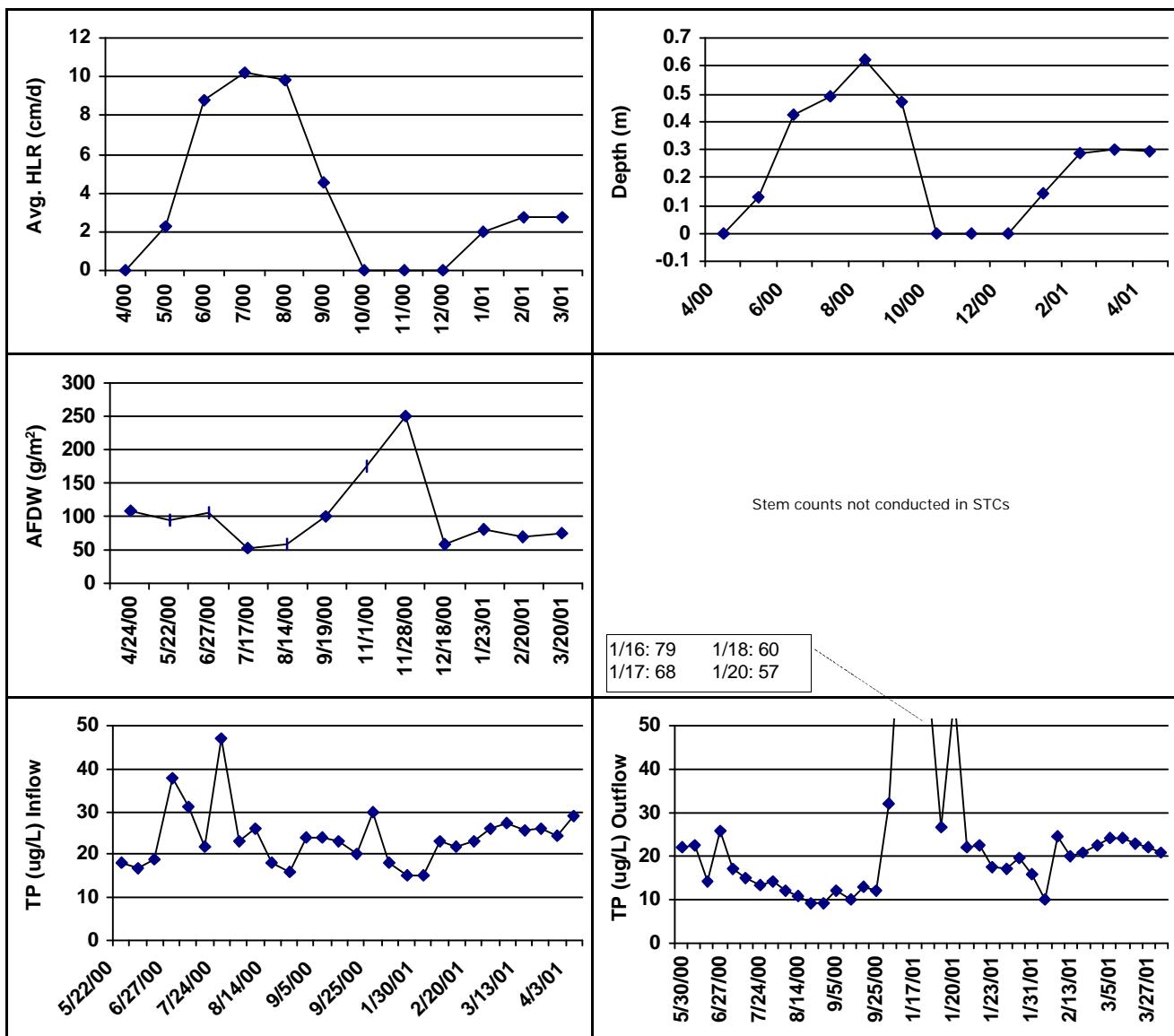
## Summary For Period

Tank/Cell	HLR (cm/d)	Depth (m)	TP in (ug/L)	TP out (ug/L)	k1 (m/y)
8	5.14	0.29	22	12	12.0
Mean	5.14	0.29	22	12	12.0

# PSTA Research and Demonstration Project

Treatment:	STC-6	Period:	4/1/2000	-	4/30/2001
Tank(s)/Cell(s):	3	Plants:	yes	Other:	
Research Scale:	Test Cell	Recirculation:	no		
Mesocosm Size:	28 x 80 m (2240m <sup>2</sup> )	Soil:	shellrock		

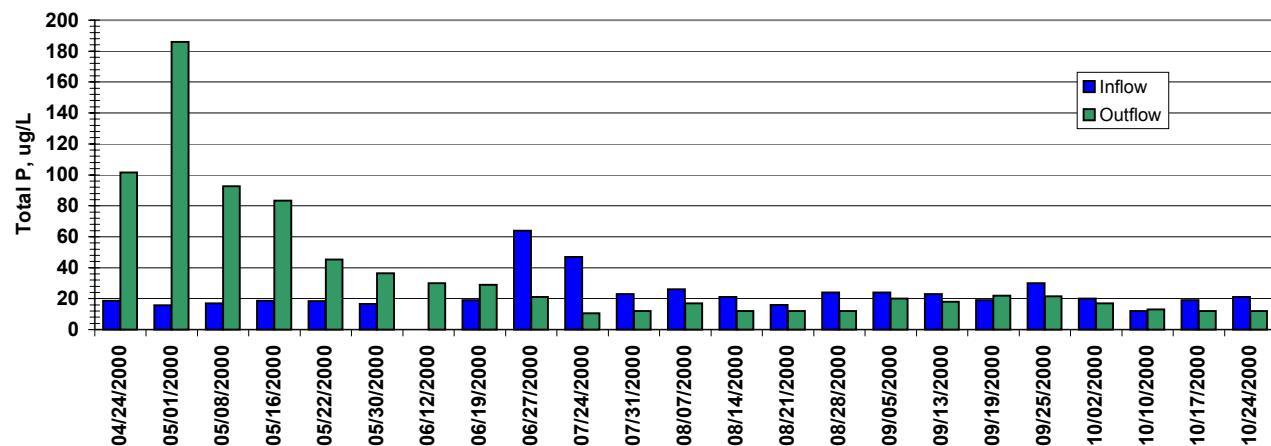
3



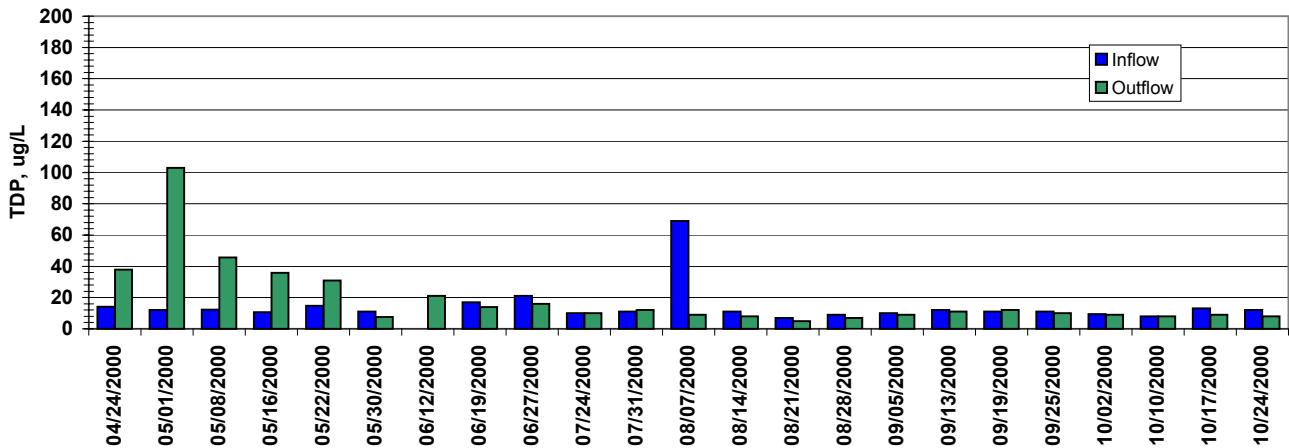
## Summary For Period

Tank/Cell	HLR (cm/d)	Depth (m)	TP in (ug/L)	TP out (ug/L)	k1 (m/y)
3	3.53	0.25	24	23	0.4
Mean	3.53	0.25	24	23	0.4

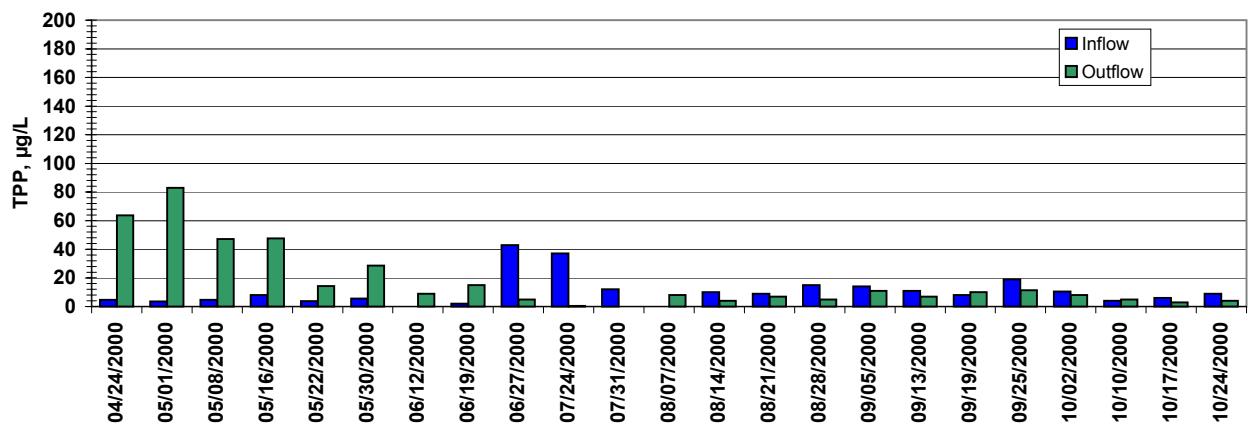
### TOTAL PHOSPHORUS



### TOTAL DISSOLVED PHOSPHORUS



### TOTAL PARTICULATE PHOSPHORUS



Note: Inflow TP and TDP data are collected by the District; missing data points are either not available or pending.

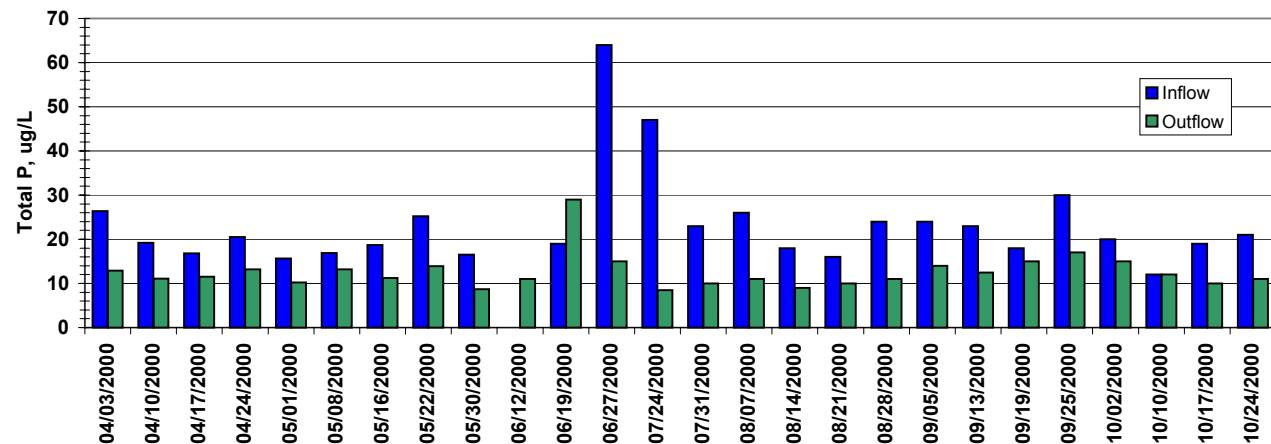
#### Exhibit C-1

Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for South Test Cell Treatment No. 4, April 2000 - Oct 2000.

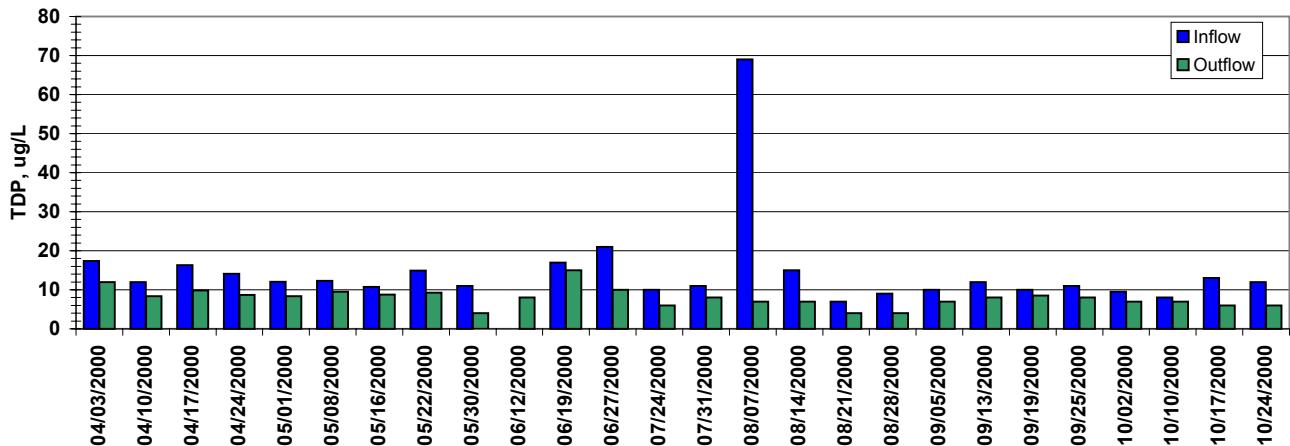
#### Key Conditions:

Substrate: Peat + Ca  
Depth: 30 cm  
HLR: 6 cm/day

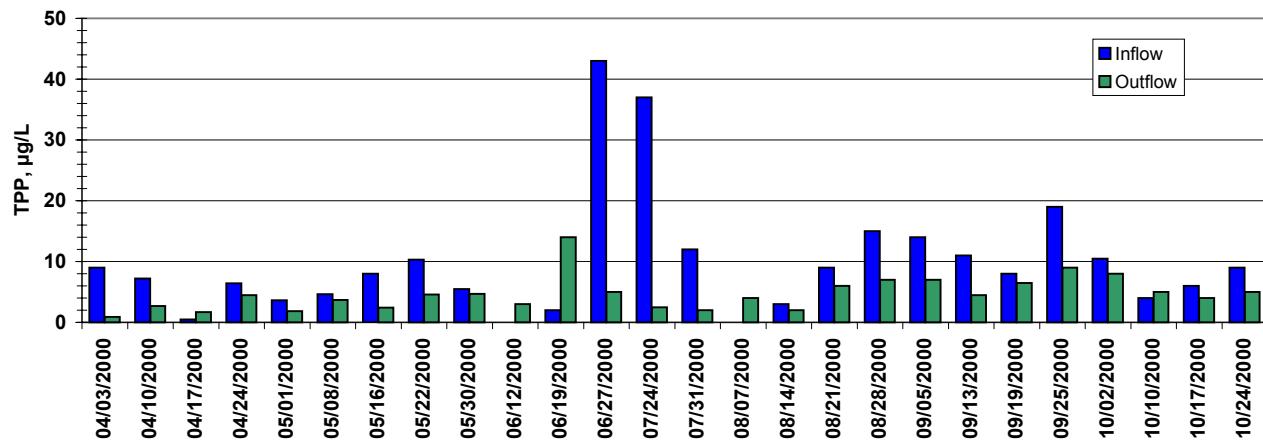
### TOTAL PHOSPHORUS



### TOTAL DISSOLVED PHOSPHORUS



### TOTAL PARTICULATE PHOSPHORUS



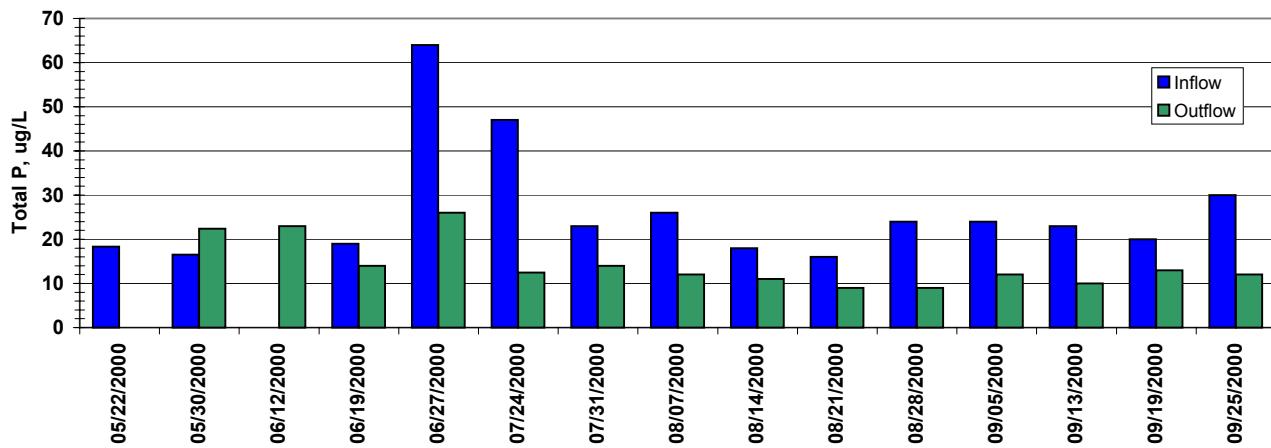
Note: Inflow TP and TDP data are collected by the District; missing data points are either not available or pending.

#### Exhibit C-2

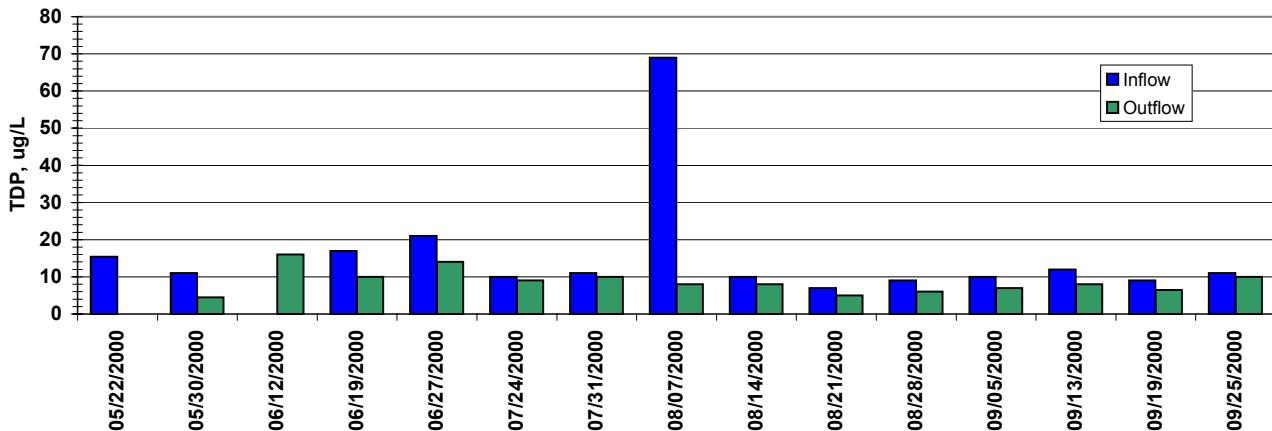
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for South Test Cell Treatment No. 5, April 2000 - Oct 2000.

Key Conditions:			
Substrate:	Shellrock		
Depth:	30 cm		
HLR:	6 cm/day		

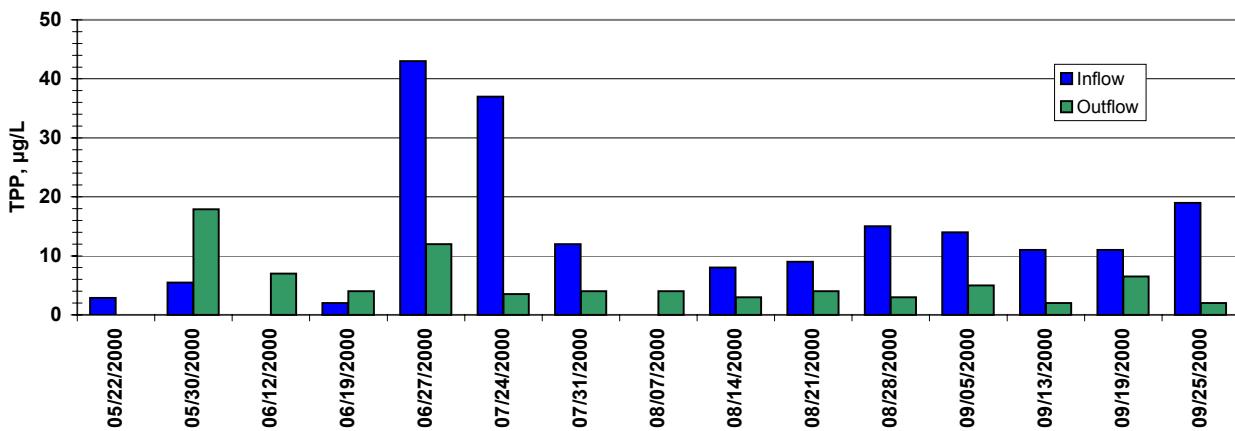
### TOTAL PHOSPHORUS



### TOTAL DISSOLVED PHOSPHORUS



### TOTAL PARTICULATE PHOSPHORUS



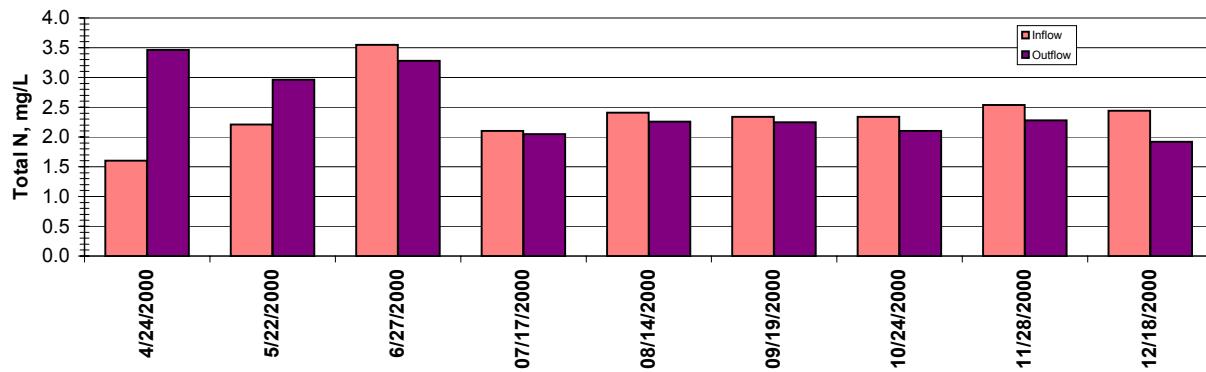
Note: Inflow TP and TDP data are collected by the District; missing data points are either not available or pending.

### Exhibit C-3

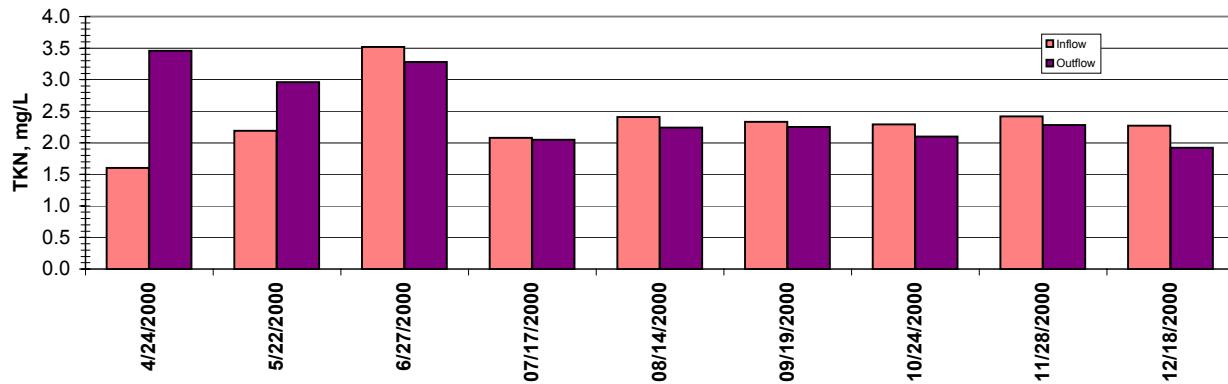
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for South Test Cell Treatment No. 6, April 2000 - Oct 2000.

Key Conditions:			
Substrate:	Shellrock		
Depth:	0 - 30 cm		
HLR:	0 - 12 cm/day		

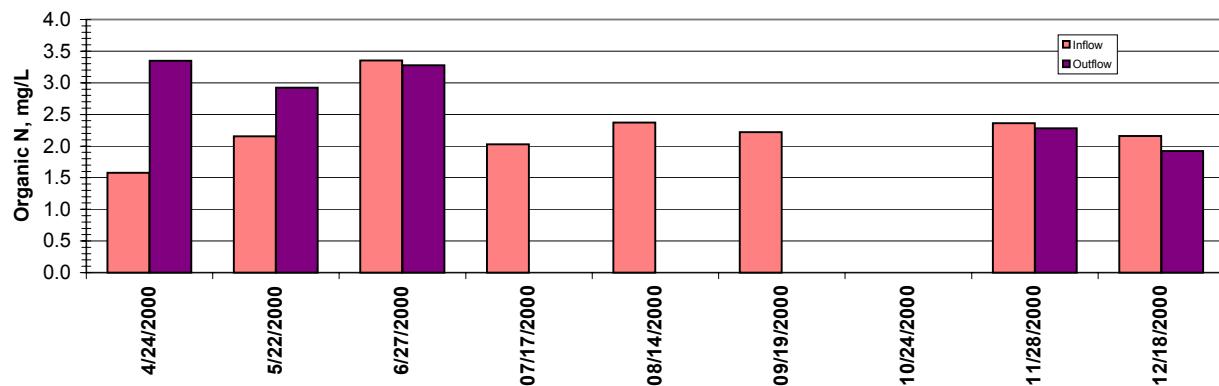
### TOTAL NITROGEN



### TOTAL KJELDAHL NITROGEN



### ORGANIC NITROGEN

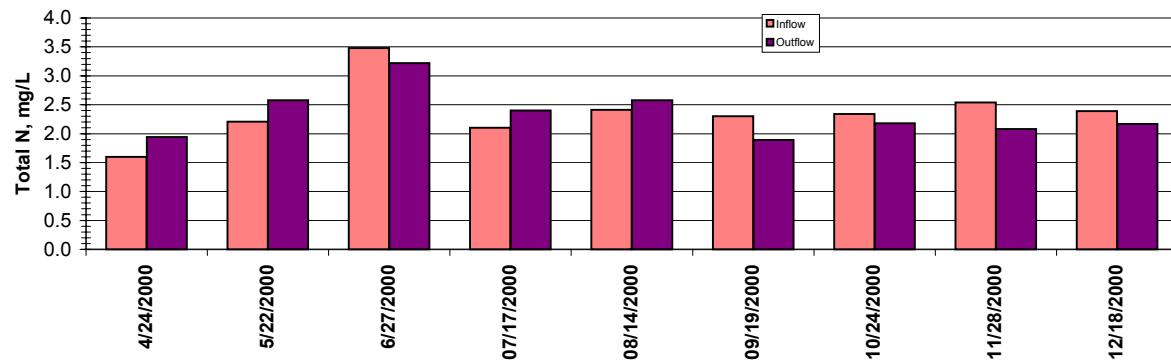


### Exhibit C-4

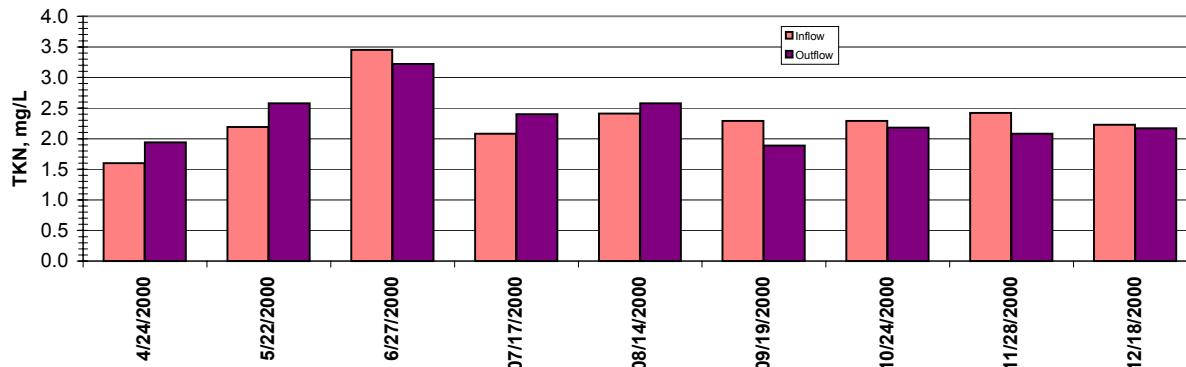
Inflow and Outflow Weekly Average Values for Total Nitrogen, Total Kjeldahl Nitrogen and Organic Nitrogen for South Test Cell Treatment No. 4, April 2000 - December 2000.

Key Conditions:			
Substrate:	Peat + Ca		
Depth:	30 cm		
HLR:	6 cm/day		

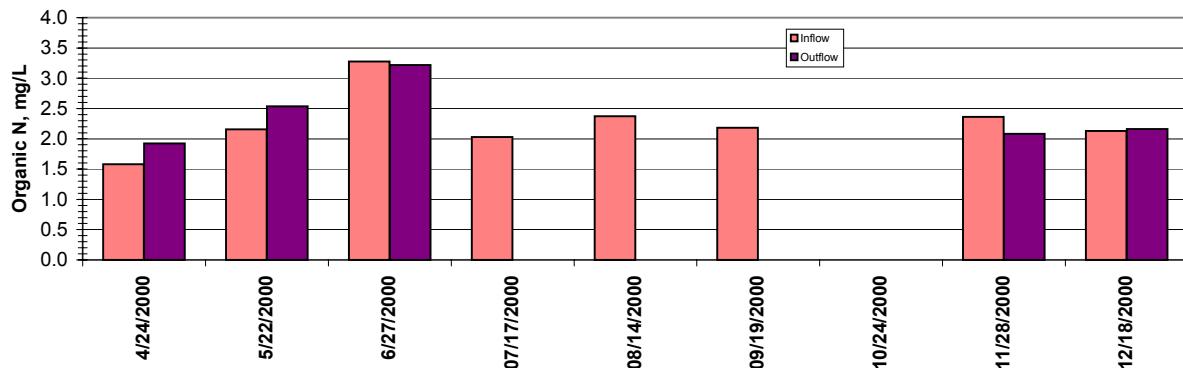
### TOTAL NITROGEN



### TOTAL KJELDAHL NITROGEN



### ORGANIC NITROGEN

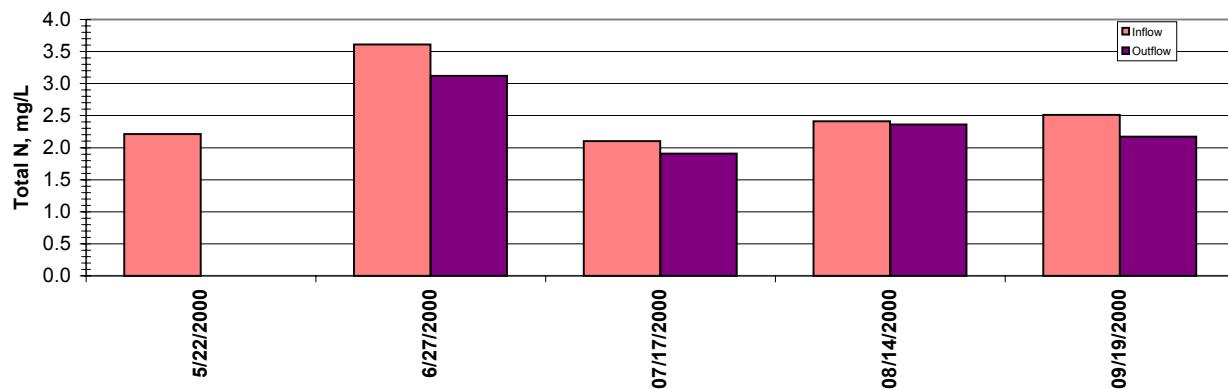


#### Exhibit C-5

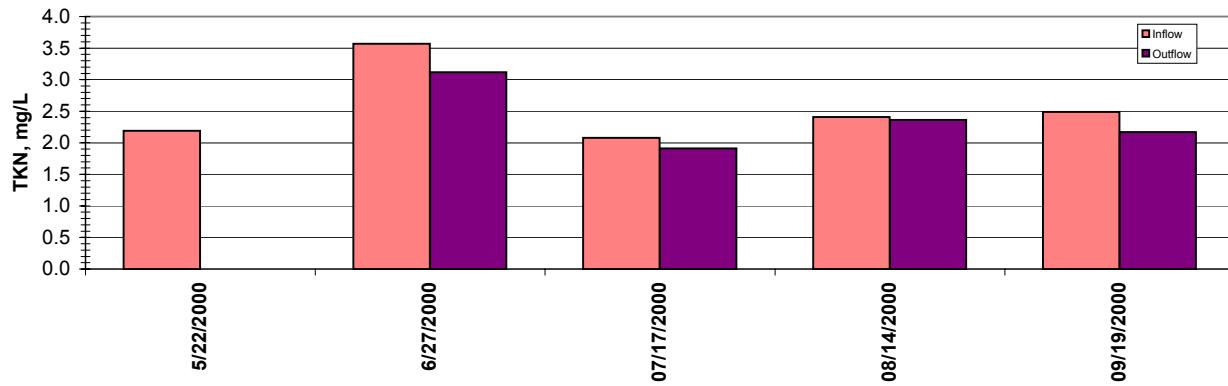
Inflow and Outflow Weekly Average Values for Total Nitrogen, Total Kjeldahl Nitrogen and Organic Nitrogen for South Test Cell Treatment No. 5, April 2000 - December 2000.

Key Conditions:	
Substrate:	Shellrock
Depth:	30 cm
HLR:	6 cm/day

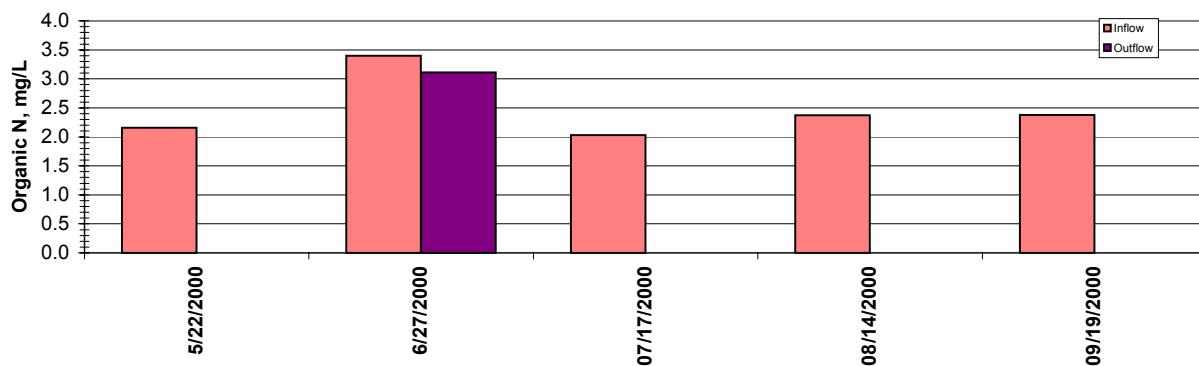
### TOTAL NITROGEN



### TOTAL KJELDAHL NITROGEN



### ORGANIC NITROGEN



Note: Treatment in dry down mode; no outflow samples taken from 3/9/00- 5/30/00.  
South Test Cell Treatment No. 6 did not receive inflow October to December, 2000.

### Exhibit C-6

Inflow and Outflow Weekly Average Values for Total Nitrogen, Total Kjeldahl Nitrogen and Organic Nitrogen for South Test Cell Treatment No. 6, May 2000 - December 2000.

Key Conditions:			
Substrate:	Shellrock		
Depth:	0 - 30 cm		
HLR:	0 - 12 cm/day		

**APPENDIX D**

## **Key Date Summary**

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## APPENDIX D

# Key Date Summary

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Dates of key activities conducted at the Porta-PSTAs and PSTA Test Cells are provided below for the study period from January 1999 to December 2000.

### **January 1999**

- **01-05-99:** Filled Porta-PSTAs with soils. Planted *Eleocharis cellulosa* into Porta-PSTAs (two to three plant clumps per square meter).
- **01-06-99:** Placed WCA-2A periphyton/bladderwort mix in all Test Cells and in all Porta-PSTA tanks except PP-21 and 22.
- **01-07-99:** Installed aluminum scaffold boardwalks in Test Cells.
- **01-08-99:** Porta-PSTAs filled to 50 cm.
- **01-12-99:** Valves opened at Test Cells. Weirs raised to 15.5 ft. national geodetic vertical datum (NGVD).
- **01-13-99:** Porta-PSTAs 1, 4, 9, 10, 23, and 24 drained and repaired for leaks.
- **01-14-99:** Water turned on at Porta-PSTAs 1, 4, 10, 12, 23, and 24 to bring up water level. Water to all Porta PSTAs turned off at end of day. Test Cell weirs adjusted to 16.0 ft. NGVD.
- **01-20-99:** Staff gauges installed in Porta-PSTAs. Porta-PSTAs filled and flows turned off at end of day for leak testing. Weir heights of all Test Cells raised to 16.5 ft. NGVD.
- **01-27-99:** Test Cell weir heights lowered to 15.5 ft. NGVD. Flow to Porta-PSTA 7 turned on for preliminary tracer study (250 mL/min).

### **February 1999**

- **02-20-99:** Plant material and substrate removed from Porta-PSTAs 16, 19, 20, and 21 for leak repairs.
- **02-12-99:** All Test Cell weir heights raised to 16.5 ft. NGVD.
- **02-17-99:** Weir height in Test Cell 8 lowered to 16.2 ft. NGVD for feldspar deployment.
- **02-18-99:** Weir height in Test Cell 8 raised to 16.5 ft. NGVD. Fiberglass repair crew replaced Porta-PSTAs 20 and 21; inflows to these tanks began. Porta-PSTAs 16 and 19 removed for repair by fiberglass repair crew.
- **02-22-99:** Adjusted Test Cell weir heights to 16.05 ft. NGVD in TC-3, 16.12 ft. NGVD in TC-8, and 16.3 ft. NGVD in TC-13 to try to reach goal of 16.5 ft. on staff gauge.

### **March 1999**

- **03-03-99:** Substrate removed from Porta-PSTA 2 for leak repair. Porta-PSTAs 1, 3, 16, 19, and 22 filled. Inflow to Head Tank stopped because of canal treatment.
- **03-17-99:** Flow to Head Tank resumed. All Porta-PSTAs filled.
- **03-18-99:** All Porta-PSTAs filled and valves then closed except PP-23.
- **03-19-99:** Porta-PSTA 23 and Head Tank flows stopped. Feldspar deployed at end of east walkway in TC-13.
- **03-23-99:** Porta-PSTAs 19 and 20 drained and sand substrate added, then macrophytes planted. Tanks refilled. Porta-PSTAs 16, 21, 23 and 24 drained.
- **03-24-99:** Shellrock added to Porta-PSTA 16, peat added to Porta-PSTA 21. Macrophytes planted in Porta-PSTA 16 and water levels increased in both tanks.
- **03-25-99:** Shellrock added to Porta-PSTA 23. Plants added and flow restarted. Test Cell 3 weir lowered to 16.0 ft. NGVD.
- **03-29-99:** Water not flowing from Head Cell to Test Cells; sampling event postponed until next day.

### **April 1999**

- **04-01-99:** Porta-PSTA 2 replaced with new tank. Supplemental Braces installed on PP-23 and 24; PP-7, 10, 11, 13, and 14 re-glassed with new braces along rib. Shellrock substrate added to PP 2 and replanted with spike rush.
- **04-02-99:** Outflow pipes on PP-3 and 7 changed to 30 cm height. Outflow pipe missing from PP-1 so pipe from PP 23 moved to PP 11. Silicon cement used to fix leaking outflow points on PP-12, 13, and 14.
- **04-03-99:** Added outflow pipe to PP-23 and started inflow. Reduced inflows on Porta-PSTAs 1-22 to the 45 setting on the inflow valve; PP-24 flow reduced. Inflow to Head Tank reduced to avoid overflow. Cleaned outflow tube on PP-3 to keep tank from overfilling.
- **04-07-99:** Lowered water in PP-4 for leak repair.
- **04-08-99:** Raised outflow point on PP-11 and 18 to the 60-cm level.
- **04-09-99:** Turned off flows to PP-4, 7, 11, 18, and 20 for leak test. Lowered weir in TC-3 by 1.875 in., TC-8 by 1 in., and TC-13 by 1 in.
- **04-12-99:** Restarted flows to tanks 4, 7, 11, 18, and 20 after leak test.
- **04-17-99:** Changed outflow level in PP-1, 6, and 15 from 60 cm to 30 cm and flows reduced to 170 mL/min.
- **04-19-99:** Lowered outflow point in PP-18 to 30 cm. Lowered weir in TC-3 to 15.3 ft. NGVD.

- **04-22-99:** Lowered weir in TC-3 to a height above grate of 10.5 in.
- **04-23-99:** Drained PP-18 for repairs.
- **04-24-99:** Flow shut off and water level dropped in PP-4 to fix leak.
- **04-27-99:** Lowered weirs in TC-8 and 13 by 0.10 ft.
- **04-30-99:** Set weir for TC-3 to 15.3 ft. NGVD.

### **May 1999**

- **05-04-99:** Raised weir in TC-8 from 15.70 ft to 15.75 ft. NGVD.
- **05-05-99:** Raised weir in TC-3 by 0.3 tenths and in TC-8 by 0.5 tenths.
- **05-17-99:** Pump transporting water to Head Tank at Porta-PSTAs stopped.
- **05-18-99:** Repaired pump to Head Tank at Porta-PSTAs, flow resumed.
- **05-24-99:** Leak in PP-11 caused water levels to drop, no sample collected.
- **05-27-99:** Raised weir in TC-13 to 16.2 ft. NGVD in an attempt to reach cell water depth of 16.5 ft. NGVD. All Porta-PSTAs except PP-23 and 24 partially drained for repairs and feldspar addition.
- **05-29-99:** Replaced drain plugs and outflow drains in all Porta-PSTAs, then filled all tanks back to operational level. Flow to TC-3 shut off for approximately 2 hours for repairs.

### **June 1999**

- **06-01-99:** Lowered water level in PP-22 to repair leak.
- **06-02-99:** Repaired leak in PP-22.
- **06-03-99:** Raised outflow points in PP-1, 6, and 15 to 60 cm level and set flows to 320 mL/min.
- **06-09-99:** Flow to Porta-PSTA Head Tank stopped between 15:00 to 15:30, Head Tank dry.
- **06-10-99:** Raised outflow levels of tanks 1, 6, and 15 to 70 cm. Pump to Porta-PSTA Head Tank still not operational.
- **06-11-99:** Set up temporary pump and garden hose to supply water to Porta-PSTA Head Tank over the weekend.
- **06-17-99:** Installed new larger temporary pump to supply water to Porta-PSTA Head Tank. District pumps still not operational.
- **06-18-99:** Flow to Head Tank from temporary pump too low. Assembled new inflow tube for hose to keep it from clogging. Flow to Head Tank via temporary pump restored.

- **06-21-99:** Temporary pump to Head Tank lost prime over the weekend. Re-established flow to Head Tank at 08:45.
- **06-22-99:** District pumps that supply water to Porta-PSTA Head Tank back online.
- **06-28-99:** District pumps to Porta-PSTA Head Tank not functioning. Temporary pump still working, Head Tank has water, all Porta-PSTAs have flow.

### **July 1999**

- **07-01-99:** Increased flows in PP-1, 6, and 15 to 370 mL/min. District pump started up and began adding water to Head Tank.
- **07-15-99:** District pump to Porta-PSTA Head Tank not running. Temporary pump running fine, Head Tank full.
- **07-21-99:** District pump to Porta-PSTA Head Tank not running.
- **07-26-99:** District pump to Porta-PSTA Head Tank still not running.
- **07-29-99:** District pump to Porta-PSTA Head Tank ran on and off during the day.

### **August 1999**

- **08-02-99:** District pump to Porta-PSTA Head Tank up and running.
- **08-03-99:** Removed small temporary Porta-PSTA Head Tank pump from canal since district pump is online.
- **08-05-99:** District pump down for repairs, back online at 12:45. Set inflows for tanks 1, 6, and 15 to 430 mL/min. Pulled 11 cattail seedlings from PP-11.

### **September 1999**

- **09-02-99:** Raise weir in TC-3 from 16.65 ft. NGVD to new height of 16.8 ft. NGVD.
- **09-10-99:** Changed orifice on TC-3 to 1.5 in.

### **October 1999**

- **10-01-99:** Adjusted inflow pipe on TC-13 because it had been leaking water. Repaired it so that water is flowing through distribution pipe once again.
- **10-07-99:** Increased flows in Porta-PSTAs to 1,200 mL/min in tanks 23 and 24, 800 mL/min in tanks 2, 13, and 16, and 400 mL/min in all other tanks in an attempt to keep flows from stopping between calibration days. Removed screens from inflow manifold line. Changed orifice in TC-3 from 1.5 in to 1 in.

### **November 1999**

- **11-04-99:** Lowered weir in TC-3 to 16.00 ft. NGVD, orifice changed to 0.75 in. Lowered outflow point on Porta-PSTAs 1, 6, and 15 to 30 cm.
- **11-23-99:** Outflow valve on Porta-PSTA NE line was changed out; water to Porta-PSTAs was shut off for 1 hr.

## **December 1999**

- **12-02-99:** Lowered weir in TC-3 to 15.3 ft. NGVD. Lowered flow in Porta-PSTAs 1, 6, and 15 to 80 mL/min.

## **January 2000**

- **01-06-00:** Lowered weir for TC-3 to 14.8 ft. NGVD, changed orifice to 1.00 in. Lowered outflow point on Porta-PSTAs 1, 6, and 15 to 10 cm and increased flows to 260 mL/min.
- **01-13-00:** Used siphon to lower water levels in tanks 2, 13, and 16 to 30 cm and set flows to 800 mL/min. Lowered weir in TC-8 by 12 in. and shut off flow to TC-13. Shut off flows in Porta-PSTAs 4, 7, 8, 9, 11, 18, and 20 to begin batch experiment.
- **01-27-00:** Re-circulation pumps were added to tanks 4, 7, 8, 9, 11, 18, and 20 as part of the batch experiment.

## **February 2000**

- **02-03-00:** Lowered weir in TC-3 by 0.1 ft. NGVD. Set flows in Porta-PSTAs 1, 6, and 15 to 205 mL/min.
- **02-14-00:** Lowered weir in TC-3 by 0.75 ft. in an attempt to reach target water depth of 0.2 ft. Lowered weir in TC-8 by 0.4 ft. in an attempt to reach target water depth of 1.0 ft.

## **March 2000**

- **03-06-00:** Shut off inflow and lowered weir in TC-3 to 14.2 ft. NGVD to drain cell for dry down experiment.
- **03-07-00:** Lowered weir in TC-13 to 14.5 ft. NGVD to drain cell.
- **03-14-00:** Cleared vegetation and dug a hole near TC-13 outflow pipe to facilitate drying of the cell.
- **03-16-00:** Re-circulation pumps removed from PP-4, 7, 8, 9, 11, 18 and 20. Shut off inflows to PP-1, 6, 15, 21, and 22. Used siphon to drain water from PP-4, 7, 8, 9, 11, 18, 20, 21, and 22. Set flows for all remaining PP to 250 mL/min and 750 mL/min for 23 and 24.
- **03-20-00:** Harvested spikerush from PP-9, 11, and 18 and save to replant tanks later. Harvested periphyton mat from PP-4, 7, 8, and 20 and save to restock PP later. Drained PP-4, 7, 8, 20, 21, and 22. Removed sediment from PP-4, 7, and 8.
- **03-21-00:** Removed sediment from PP-21 and 22. Rinse PP-4, 7, 8, 20, 21, and 22 with HCl. Counted and removed snails from PP-1, 2, 6, 10, 12, 13, 14, 17, 23, and 24.
- **03-22-00:** Loaded limerock sediment into PP-4, 7, and 8 and rinsed limerock three times before bringing water levels up to just above the sediment. Brought water level in PP-20 up to just above sediment. Planted spike rush in PP-1, 4, 6, 7, 8, 19, and 20. Added approximately 1.5 gallons of periphyton to PP-4, 7, 8, 20, 21, and 22. Installed re-circulation pumps on tanks 2, 13, and 16. Pulled cattail seedlings: PP-3 (1), PP-6 (8), and PP-13 (2). Loosened lowest outlet point on PP-1, 6, and 15 to allow them to dry out. Herbicide applied to vegetation in TC-13.

- **03-27-00:** Installed Aquamat in PP-22. Applied approximately 9 lbs. of hydrated lime to PP-9, 11, and 18. Dug trench and cleaned out screen over outflow pipe in weir box in TC-13 to facilitate drying of cell.

#### **April 2000**

- **04-03-00:** Installed screen over intake of re-circulation pumps in PP-2, 13, and to keep them from clogging with snails. Added water to tanks 4, 7, 8, 6, and 15 to keep plants alive.
- **04-07-00:** Raised weir to 14.8 ft in TC-13. Clear all dead vegetation from TC-13 and turned on water with 1-inch orifice.
- **04-10-00:** Turned off water to TC-13, cell had approximately 3 inches of water. Added hydrated lime to 1/3 of TC-13. Added water to tanks 1, 6, and 15 to keep plants alive.
- **04-11-00:** Added lime to final 2/3 of TC-13 (sixty-eight 50-lb. bags were spread evenly throughout the cell for a total of 3,400 lbs.)
- **04-12-00:** Raised weir to 15.0 ft and turned on water. Planted spikerush in TC-13. Broadcast approximately 126 gallons of periphyton into TC-13.
- **04-13-00:** Lowered outflow point of PP-21 and 22 to 10-cm level. The 10-cm level accounts for the lack of sediment in the tanks. Because the tanks have no sediment, there is approximately 30 cm of water in the tanks. All other tanks have outflow points at 30-cm level. Turned on inflows to tanks 4, 7, 8, 9, 11, 18, 20, 21, & 22. Planted six clumps of *Eleocharis* each into PP-9, 11, and 18.
- **04-17-00:** Adjusted outflow point of PP 20 to 30cm level.

#### **May 2000**

- **05-01-00:** Re-circulation pump in PP-2 not functioning properly; removed to exchange for a new one. Drew down water with siphon in PP-11 and 20 to level below that of metal support brackets to allow for leak repair.
- **05-02-00:** Fixed leaks with epoxy in PP-11 and 20; brought water levels back up to 30-cm level.
- **05-04-00:** Installed new re-circulation pump on PP-2.
- **05-15-00:** Water in PP-1, 6, and 15 turned on and set to 350 mL/min.
- **05-18-00:** Turned on water in TC-3 with 1-inch orifice. Replaced bucket and black plastic tube back in outflow pipe; raised weir to 15.5 ft. Removed one cattail plant each from PP-6, 16, and 19.
- **05-19-00:** Raised outflow pipe on PP-1, 6, and 15 to 30-cm level.
- **05-25-00:** Aquamat in PP-22 had drifted out of place. Moved it back into its original position. Flows in Porta-PSTA were increased from 350 mL/min (750 mL/min for PP-23 and 24) to 400 mL/min (1,200 mL/min for PP-23 and 24) to keep flows from stopping between calibration days. Completed depth survey at TC-3, 8, and 13 consisting of 40

depth measurements for each cell (10 measurements along each side of the 1/3 and 2/3 walkways). Used average depth from survey to make adjustments to weirs in an attempt to reach target water depth of 1.0 ft in each Test Cell. For TC-3 average depth was 1.192 ft, and the water was still ~0.1 ft below the V-notch. Weir was lowered by 0.3 ft to a new height of 15.2 ft. For TC-8 the average depth was 0.798 ft. Weir was raised by 0.2 ft to a new height of 15.0 ft. For TC-13 the average depth was 0.84 ft. Weir was raised by 0.16 ft to a new height of 15.15 ft.

### **June 2000**

- **06-05-00:** Aquamat in PP-22 drifted out of place; moved back to its original position. Drew down water in PP-11 to repair a leak in tank.
- **06-08-00:** Aquamat in PP-22 drifted out of place; moved back to its original position. Changed orifice in TC-3 from 1 inch to 1.5 inches.

### **July 2000**

- **07-12-00:** Aquamat in PP-22 drifted out of place; moved back to its original position. Collected snails from PP-1 and 10.
- **07-13-00:** Collected snails from PP-2 through 9 and 11 through 15.
- **07-24-00:** Added ~ 1/2 gallon of *Utricularia* to PP-21. *Utricularia* was taken from west walkway of TC-3 and added to PP-21 in approximately 2 gallons of water.
- **07-27-00:** Used sprinkler head weights with zip ties to hold down Aquamat in its proper position. Collected snails from PP-16 through 21. Removed blue outflow tube from PP-21 and replaced with a more flexible tubing to fix problem with higher "recorded" outflows.
- **07-31-00:** Deployed larger sediment traps in Porta-PSTAs (one in each tank) and Test Cells (three along each walkway).

### **August 2000**

- **08-03-00:** Cut a notch in outflow collection pipe in front of PP-21 (outflow tube was being pushed up by outflow collection pipe, causing water to pool up, which in turn altered our outflow measurements).
- **08-10-00:** Entered TC-3 to clear snails, vegetation, and algae from holes in outflow stand pipes because water level was becoming too deep. Repaired hole in inflow tube for TC-13
- **08-28-00:** Installed new re-circulation pumps on PP-13 and 16.
- **08-31-00:** Entered TC-3 to clear holes in outflow stand pipes (water levels too deep).

### **September 2000**

- **09-06-00:** Installed water level recorders onto outflow boxes of Field-Scale (FS) Cells 1, 2, and 3.

- **09-07-00:** Added five bags of dried periphyton to PP-21 and 22 each for decomposition study. Made cement bucket weights to use in FS cells to hold hose from inflow pumps in place.
- **09-08-00:** Installed one water level recorder in FS inflow canal and one in outflow canal. Placed a PVC 'T' on end of FS pump hose to disperse flow so it would not be as erosive and added bucket weights to end of hose.
- **09-13-00:** Inflow to TC-3 turned off to change orifice from 1.5-in to 1-in. Lowered weir to 14.95 ft to reach target water level elevation of 15.0 ft. Could not get water turned back on; SFWMD to fix. Coastal Revegetation was on site to herbicide cattails along bank of TC-3, 8, and 13 (Coastal staff did not enter cell – only what they could reach from the bank) and also vegetation around inflow pipes, weir boxes, and walkways to allow for clear paths when taking field readings.
- **09-15-00:** Weir heights in Field-Scale Cells raised to 3 ft.
- **09-18-00:** Power outage at Porta-PSTA site. Head tank emptied. Temporary pumps installed to supply head tank with water from canal. Flow to Porta-PSTAs resumed. Recirculation pumps in PP-2 and PP-16 off because of power outage; recirculation pump in PP-13 working. Water to TC-3 still not on.
- **09-19-00:** Power restored to Porta-PSTA site. Field-Scale weir heights re-set to 2 ft.
- **09-25-00:** Rain gauge installed at Field-Scale site. Water at TC-3 still slightly overflowing weir.
- **09-27-00:** Significant amount of leakage observed through inflow (south) berm of Field-Scale cells.
- **09-28-00:** Coastal Revegetation on site at Test Cells for second herbicide application. Weir in TC-3 lowered as much as possible to help cell to dry; decision made to enter dry-out phase.

## **October 2000**

- **10-02-00 through 10-04-00:** Final Porta-PSTA quarterly event.
- **10-10-00:** Sediment traps collected at Porta-PSTAs and Test Cells.
- **10-12-00:** Field-Scale cells measured for boardwalk placement. FS Cell 1: 210 ft x 1040 ft (east side)(1,043 ft west side); FS Cell 2: 218 ft (including inner berms which average 20 ft wide) x 1,025 ft; FS Cell 3: 215 ft x 1,038 ft. Met with Bagley Environmental and Planting Services to discuss *Eleocharis* planting. Decomposition study employing 1¼-inch PVC tubes, 15-cm length, begun at Porta-PSTA site. Tubes all deployed at 2/3 point in PP-21.
- **10-14-00:** Second set of water collected at Field-Scale site for phosphorus background levels.
- **10-24-00:** Sediment traps re-deployed in Test Cells. Final decomposition bag retrieved from Porta-PSTAs.

## **November 2000**

- **11-01-00:** Oxygen diffusion study performed in TC-8 and PP-3. First set of five periphyton decomposition study tubes retrieved from PP-21.
- **11-07-00:** Oxygen diffusion study performed at PP-16.
- **11-14-00:** Oxygen diffusion study performed in PP-23. Final set of tubes removed for decomposition study.
- **11-28-00:** Photos taken at Test Cells. Stakes placed along TC3 walkways to photo-document re-wetting of periphyton mat in anticipation of water being turned back on. Valve at this point still not operational.

## **December 2000**

- **12-05-00:** Diffusion study conducted in TC-13. Finished staking TC-8 and 13 for control photos, documenting re-wetting of periphyton mat of TC-3.
- **12-06-00:** Water level recorders removed from FS site to prevent damage they might incur from scheduled blasting (for fill for FS4). All pumps off for blasting event.
- **12-18-00:** Test Cell Quarterly sampling..
- **12-20-00:** Begin installing boardwalks in Field-Scale Cells.
- **12-27-00:** Oxygen diffusion study conducted in PP-10.

**APPENDIX E**

## **Model Calibration Spreadsheets**

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**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model - South Test Cell 3**

Wetland grade = **14.259** ft

Initial P<sub>w</sub> = **0.0466096** g/m<sup>3</sup>

Time Step = **0.1** d

Starting Stage = **15.8** ft

Initial B = **24.1** g/m<sup>2</sup>

Weir Equation =  $\frac{900}{V\text{-notch}}$

Wetland Area at grade = **2240** m<sup>2</sup>

Initial P<sub>B</sub> = **0.1423** g/m<sup>2</sup>

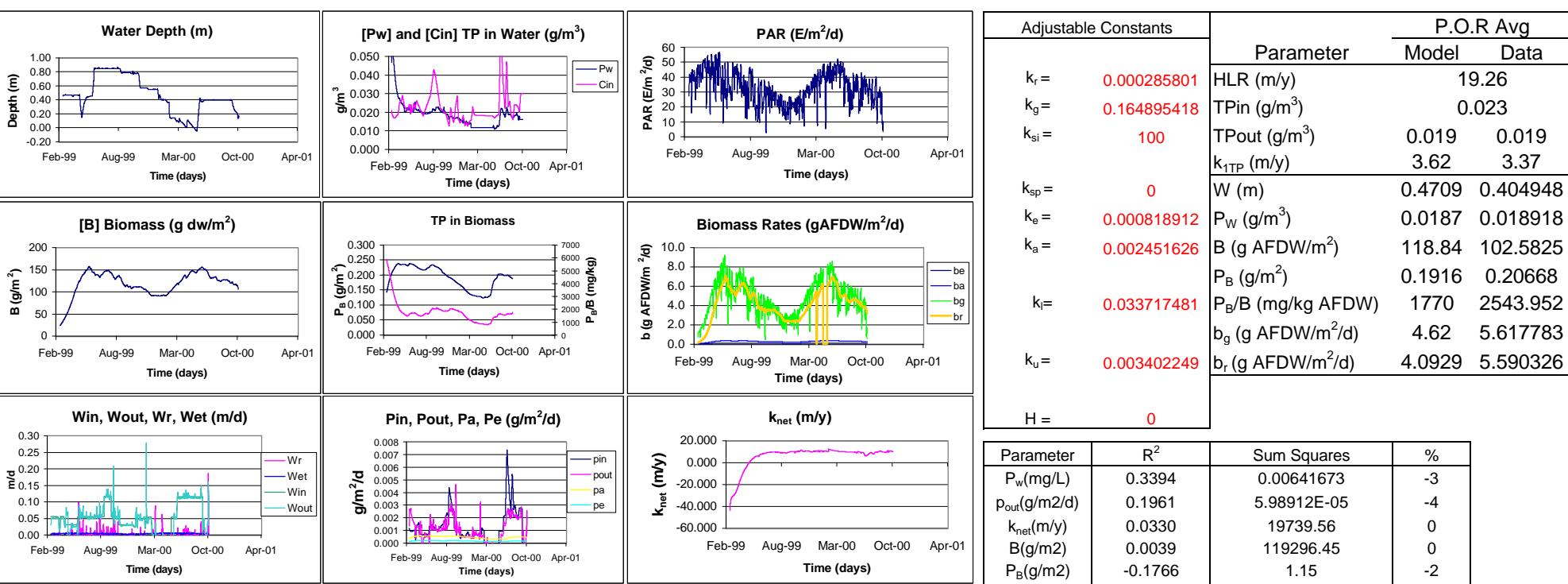
Weir Width = **1** ft

Volume below grade = **0** m<sup>3</sup>

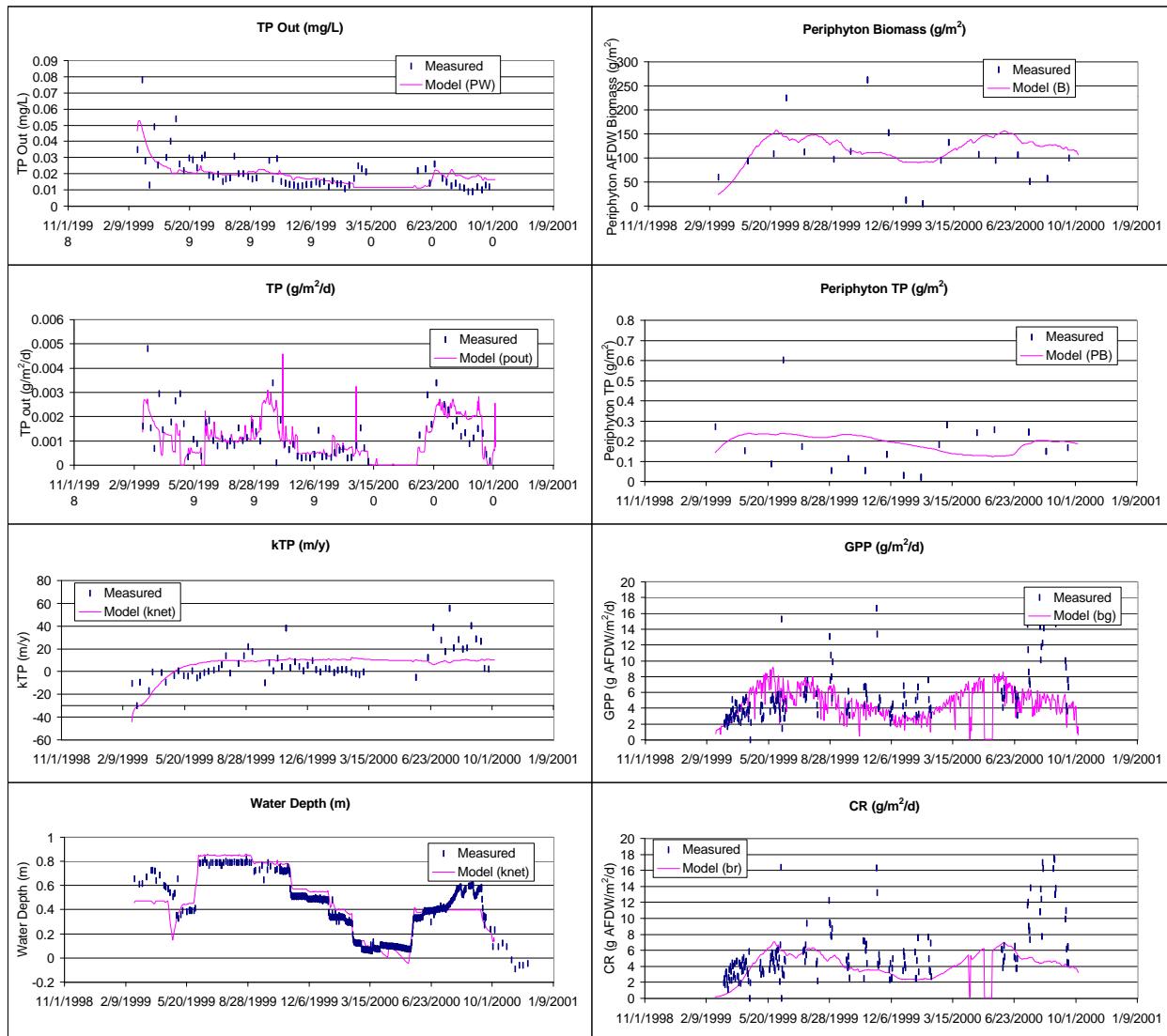
Initial P<sub>L</sub> = **0.1768** g/m<sup>2</sup>

Note: User inputs in red

Leakance Rate = **0** m/d



**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model - South Test Cell 3**



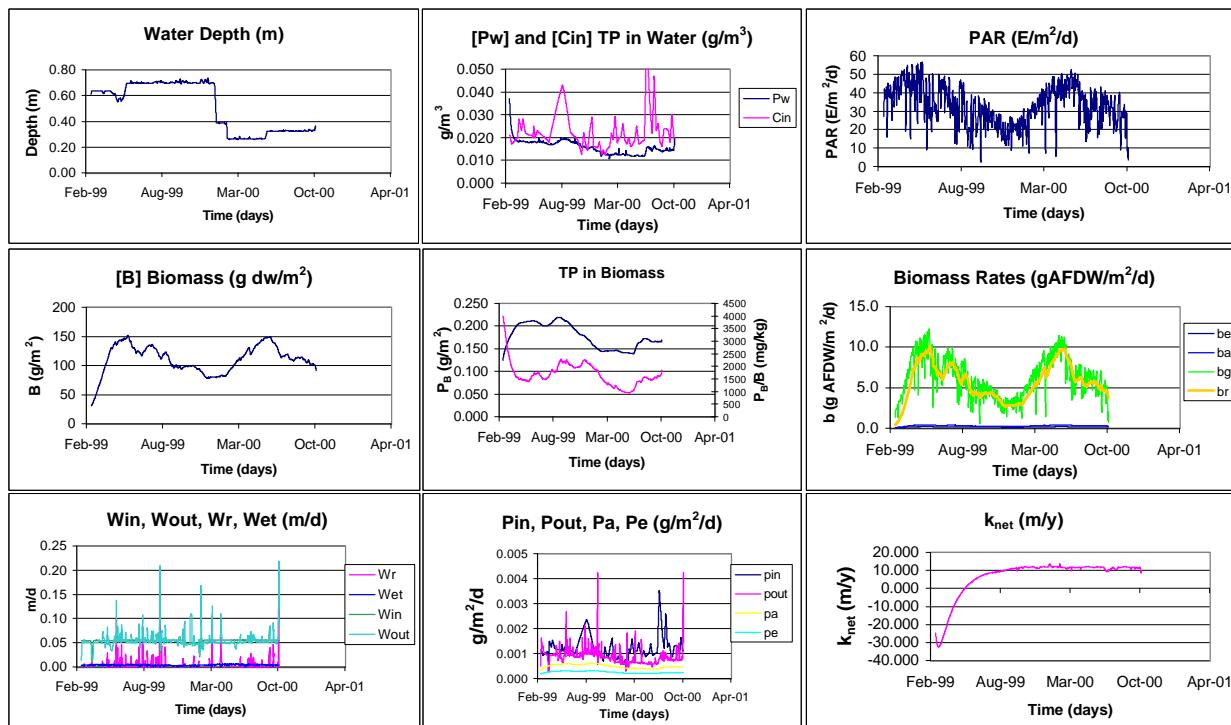
Adjustable Constants	
$k_r =$	0.000285801
$k_g =$	0.164895418
$k_{si} =$	100
$k_{sp} =$	0
$k_e =$	0.000818912
$k_a =$	0.002451626
$k_l =$	0.033717481
$k_u =$	0.003402249
$H =$	0

Parameter	R <sup>2</sup>	SS
P <sub>w</sub> (mg/L)	0.3394	0.0064
p <sub>out</sub> (g/m <sup>2</sup> /d)	0.1961	6E-05
k <sub>net</sub> (m/y)	0.033	19740
B(g AFDW/m <sup>2</sup> )	0.0039	119296
P <sub>B</sub> (g/m <sup>2</sup> )	-0.177	1.1509
P <sub>B</sub> /B (mg/kgAFDW)	-0.454	1E+08
b <sub>g</sub> (g AFDW/m <sup>2</sup> /d)	-0.1	2474.9
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	-0.223	2718.1
W(m)	0.836	3.9244

Parameter	P.O.R Avg	
	Model	Data
HLR (m/y)		19.26
TPin (g/m <sup>3</sup> )		0.023
TPout (g/m <sup>3</sup> )	0.019	0.019
k <sub>1TP</sub> (m/y)	3.62	3.37

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model - South Test Cell 8**

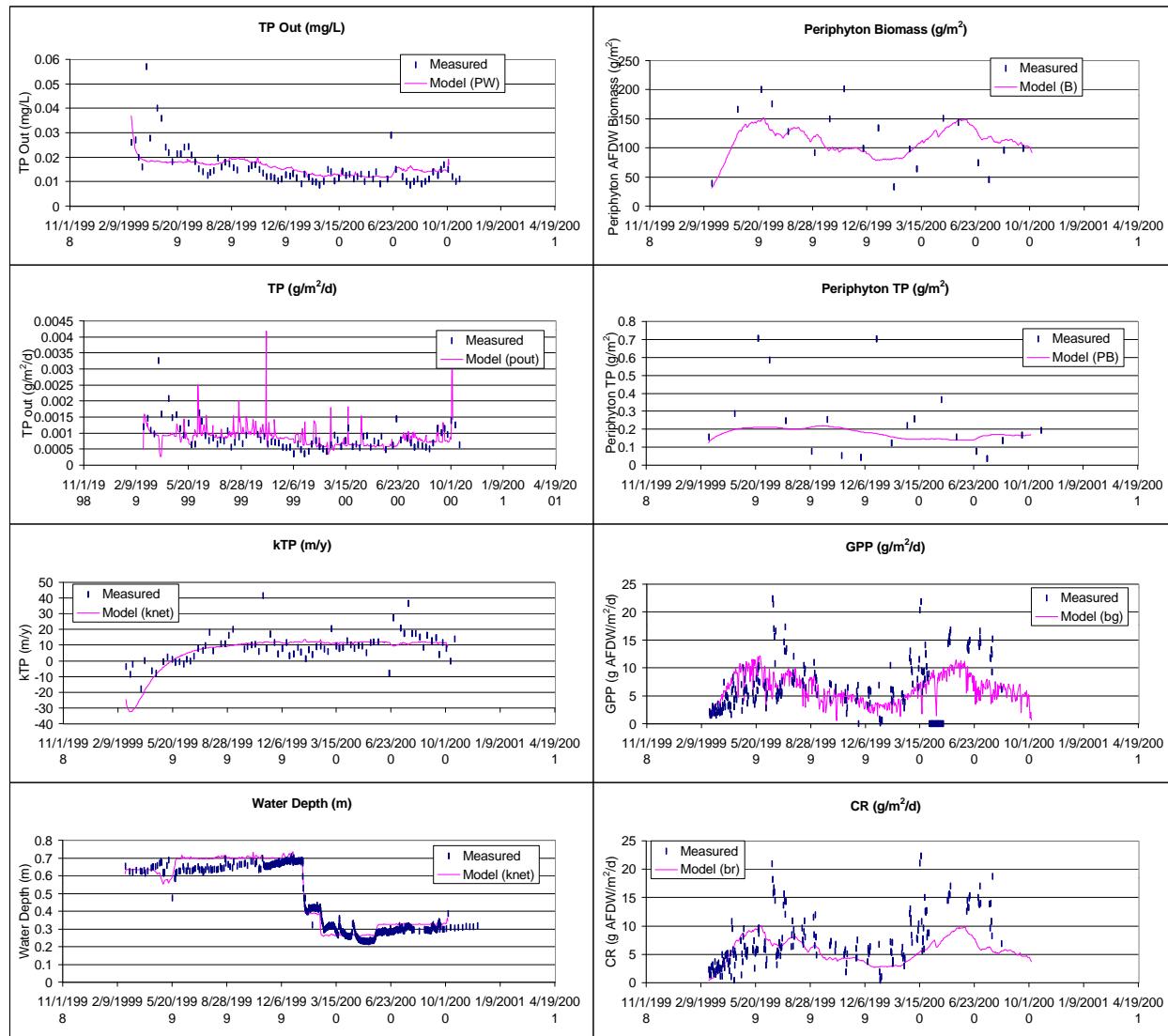
Wetland grade = 14.2 ft      Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Starting Stage = 16.2 ft      Initial B = 31.3 g/m<sup>2</sup>  
 Time Step = 0.1 d  
 Weir Equation =  90° V-notch  
 Wetland Area at grade = 2240 m<sup>2</sup>      Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Weir Width = 1 ft  
 Volume below grade = 0 m<sup>3</sup>      Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>  
 Leakage Rate = 0 m/d  
 Note: User inputs in red



Adjustable Constants	P.O.R Avg		
	Parameter	Model	Data
k <sub>r</sub> = 0.000441	HLR (m/y)	19.70	
k <sub>g</sub> = 0.227	TPin (g/m³)	0.023	
k <sub>Si</sub> = 100	TPout (g/m³)	0.016	0.015
k <sub>TP</sub> (m/y)	7.31	8.55	
k <sub>sp</sub> = 0	W (m)	0.5134	0.43867
k <sub>e</sub> = 0.00141	P <sub>w</sub> (g/m³)	0.0158	0.014825
k <sub>a</sub> = 0.00275	B (g AFDW/m²)	111.14	108.4696
k <sub>f</sub> = 0.0189	P <sub>B</sub> (g/m²)	0.1776	0.244823
k <sub>u</sub> = 0.0055	P <sub>B</sub> /B (mg/kg AFDW)	1680.8	2262.7
H = 0	b <sub>g</sub> (g AFDW/m²/d)	6.2508	6.503944
	b <sub>r</sub> (g AFDW/m²/d)	5.6871	7.327478

Parameter	R <sup>2</sup>	Sum Squares	%
P <sub>w</sub> (mg/L)	0.2242	0.004111721	34
P <sub>out</sub> (g/m <sup>2</sup> /d)	-0.1191	1.93617E-05	66
k <sub>net</sub> (m/y)	0.0211	8556.30	57
B(g/m <sup>2</sup> )	0.2315	54764.80	54
P <sub>B</sub> (g/m <sup>2</sup> )	-0.0421	1.41	-25
P <sub>B</sub> /B (mg/kg)	-0.0500	62441055.60	48
b <sub>g</sub> (g/m <sup>2</sup> /d)	-0.0612	6065.31	-145
b <sub>r</sub> (g/m <sup>2</sup> /d)	0.0379	4311.30	-59
W(m)	0.9514	0.70	82
		113	

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model - South Test Cell 8**



Adjustable Constants	
$k_r =$	0.000441
$k_g =$	0.227
$k_{si} =$	100
$k_{sp} =$	0
$k_e =$	0.00141
$k_a =$	0.00275
$k_l =$	0.0189
$k_u =$	0.0055
$H =$	0

Parameter	R <sup>2</sup>	SS
P <sub>w</sub> (mg/L)	0.2242	0.0041
p <sub>out</sub> (g/m <sup>2</sup> /d)	-0.119	2E-05
k <sub>net</sub> (m/y)	0.0211	8556.3
B(g AFDW/m <sup>2</sup> )	0.2315	54765
P <sub>B</sub> (g/m <sup>2</sup> )	-0.042	1.4066
P <sub>B</sub> /B (mg/kgAFDW)	-0.05	6E+07
b <sub>g</sub> (g AFDW/m <sup>2</sup> /d)	-0.061	6065.3
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	0.0379	4311.3
W(m)	0.9514	0.7018

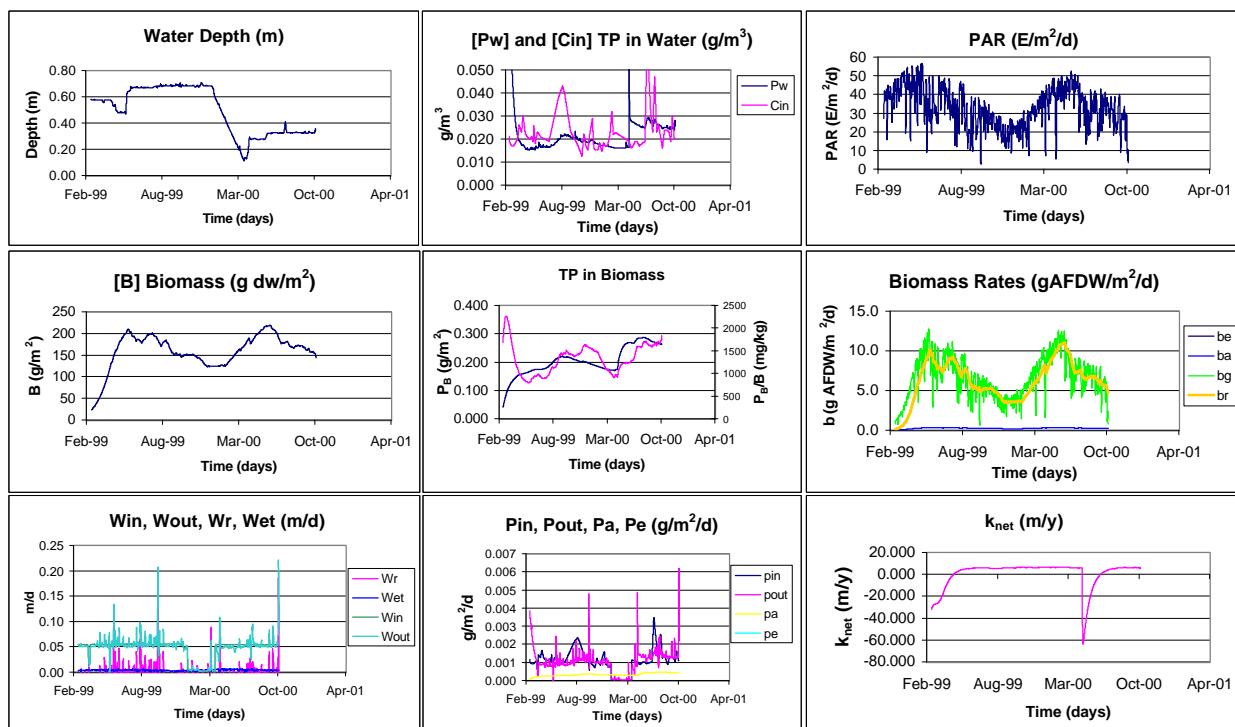
Parameter	P.O.R Avg	
	Model	Data
HLR (m/y)		19.70
TPin (g/m <sup>3</sup> )		0.023
TPout (g/m <sup>3</sup> )	0.016	0.015
k <sub>1TP</sub> (m/y)	7.31	8.55

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model - South Test Cell 13**

Wetland grade = **14.3** ft      Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Starting Stage = **16.2** ft      Initial B = **23.8** g/m<sup>2</sup>  
 Wetland Area at grade = **2240** m<sup>2</sup>      Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>      Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>  
 Leakance Rate = **0** m/d      Second P<sub>w</sub> = **0.1** g/m<sup>3</sup>

Time Step = **0.1** d  
 Weir Equation = **900 V-notch**  
 Weir Width = **1** ft

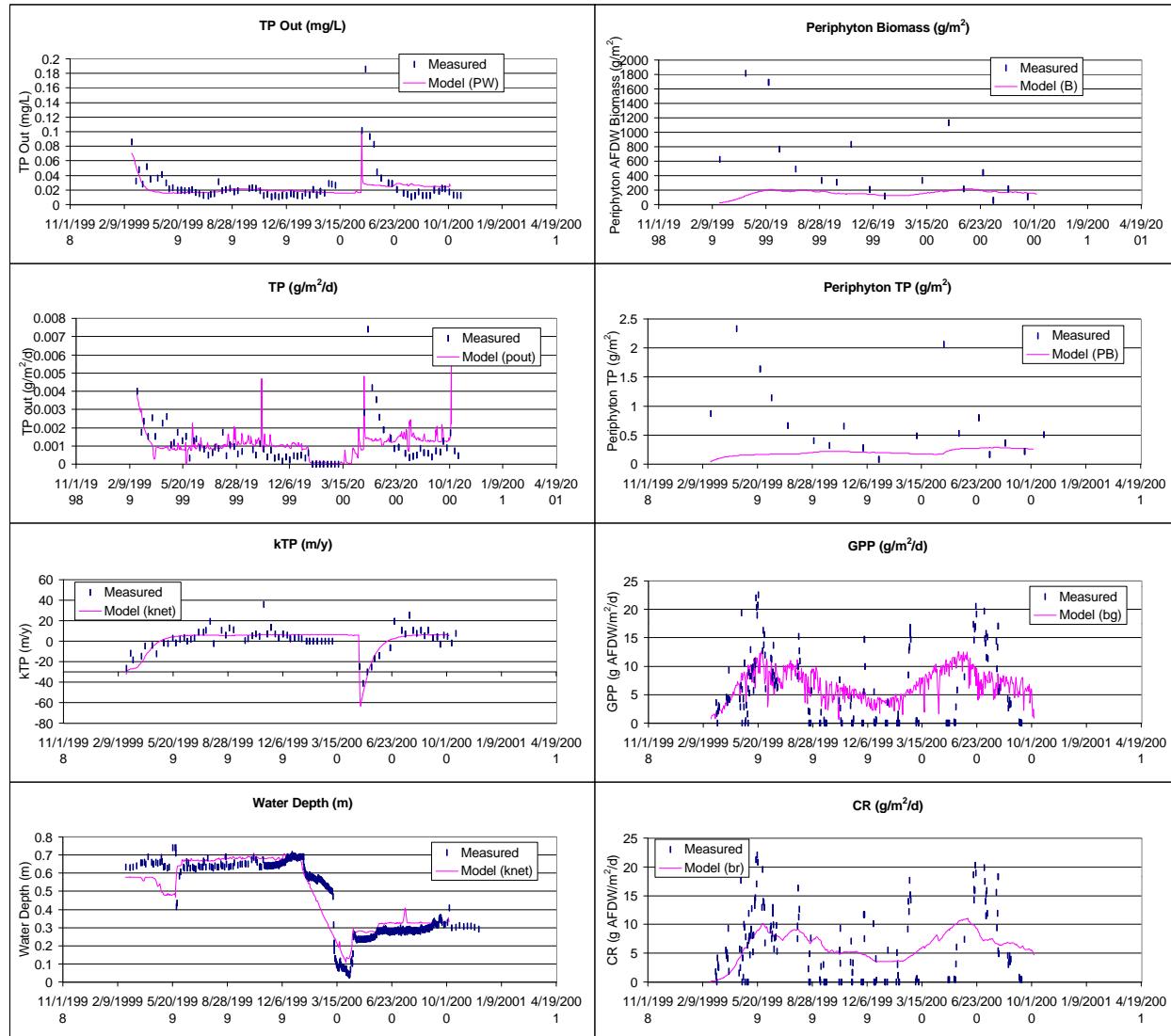
Note: User inputs in red



Parameter	P.O.R Avg		
		Model	Data
HLR (m/y)	0.00023	17.05	
TPin (g/m³)	0.171	0.023	
TPout (g/m³)	100	0.021	0.024
k <sub>TP</sub> (m/y)	1.31	-0.65	
W (m)	0	0.4953	0.436495
P <sub>w</sub> (g/m <sup>3</sup> )	0	0.0215	0.024077
B (g AFDW/m <sup>2</sup> )	0	160.01	522.209
P <sub>B</sub> (g/m <sup>2</sup> )	0	0.203	0.682526
P <sub>B</sub> /B (mg/kg AFDW)	0	1324.4	1536.108
b <sub>g</sub> (g AFDW/m <sup>2</sup> /d)	0	6.6939	6.222247
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	0	6.2395	6.665464

Parameter	R <sup>2</sup>	Sum Squares	%
P <sub>w</sub> (mg/L)	0.2372	0.040825926	-552
P <sub>out</sub> (g/m <sup>2</sup> /d)	0.1518	9.44753E-05	-65
k <sub>net</sub> (m/y)	0.5911	5047.66	74
B(g/m <sup>2</sup> )	-0.4590	9677743.23	-8012
P <sub>B</sub> (g/m <sup>2</sup> )	-0.6890	15.63	-1286
P <sub>B</sub> /B (mg/kg)	-0.1198	8832282.43	93
b <sub>g</sub> (g/m <sup>2</sup> /d)	0.1816	5743.52	-132
b <sub>r</sub> (g/m <sup>2</sup> /d)	0.1823	5399.74	-99
W(m)	0.8633	2.62	33
			-9946

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model - South Test Cell 13**



Adjustable Constants	
$k_r =$	0.00023
$k_g =$	0.171
$k_{si} =$	100
$k_{sp} =$	0
$k_e =$	0
$k_a =$	0.00158
$k_l =$	0.0519
$k_u =$	0.00252
$H =$	0

Parameter	$R^2$	SS
$P_w(\text{mg/L})$	0.2372	0.0408
$p_{out}(\text{g}/\text{m}^2/\text{d})$	0.1518	9E-05
$k_{net}(\text{m/y})$	0.5911	5047.7
$B(\text{g AFDW}/\text{m}^2)$	-0.459	1E+07
$P_B(\text{g}/\text{m}^2)$	-0.689	15.632
$P_B/B (\text{mg/kgAFDW})$	-0.12	9E+06
$b_g(\text{g AFDW}/\text{m}^2/\text{d})$	0.1816	5743.5
$b_r(\text{g AFDW}/\text{m}^2/\text{d})$	0.1823	5399.7
$W(\text{m})$	0.8633	2.6151

Parameter	P.O.R Avg	
	Model	Data
HLR (m/y)		17.05
TPin ( $\text{g}/\text{m}^3$ )		0.023
TPout ( $\text{g}/\text{m}^3$ )	0.021	0.024
$k_{TP} (\text{m/y})$	1.31	-0.65

APPENDIX F

## **Model Results**

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## **APPENDIX F**

# **Model Results**

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This appendix provides detailed PSTA Forecast Model results for a variety of operation and management scenarios.

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

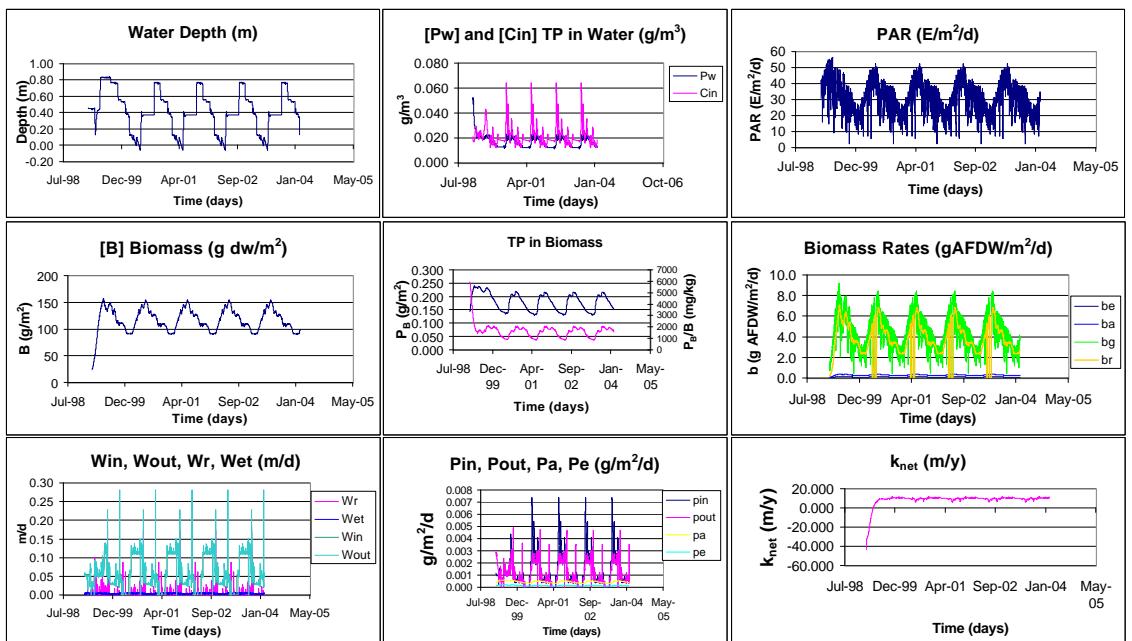
Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90e V-notch  
 Weir Width = 1 ft

CELL	TC 3
HLR (cm/d)	variable
DEPTH (ft)	variable

Note: User inputs in red



Adjustable Constants	Parameter	P.O.R Avg
k <sub>r</sub> = 0.000286	HLR (m/y)	20.68
k <sub>g</sub> = 0.165	TPin (g/m³)	0.021
k <sub>si</sub> = 100	TPout (g/m³)	0.017
k <sub>1TP</sub> (m/y)	k <sub>1TP</sub> (m/y)	4.83
k <sub>sp</sub> = 0	W (m)	0.4195
k <sub>e</sub> = 0.000819	P <sub>w</sub> (g/m³)	0.0169
k <sub>a</sub> = 0.00245	B (g AFDW/m²)	116.75
k <sub>f</sub> = 0.0337	P <sub>B</sub> (g/m²)	0.1806
k <sub>u</sub> = 0.0034	P <sub>B</sub> /B (mg/kg AFDW)	1630.4
H = 0	b <sub>q</sub> (g AFDW/m²/d)	4.2024
	b <sub>r</sub> (g AFDW/m²/d)	3.7801

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

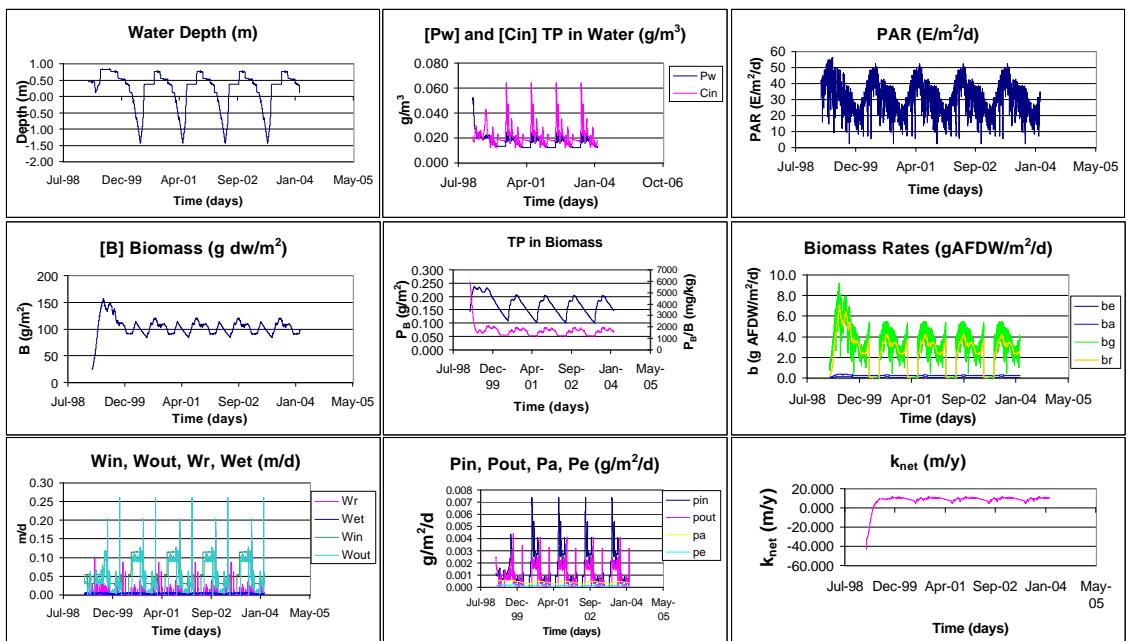
Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0.02 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90e V-notch  
 Weir Width = 1 ft

CELL	TC 3
HLR (cm/d)	variable
DEPTH (ft)	variable

Note: User inputs in red



Adjustable Constants	Parameter	P.O.R Avg
k <sub>r</sub> = 0.000286	HLR (m/y)	20.68
k <sub>g</sub> = 0.165	TPin (g/m <sup>3</sup> )	0.021
k <sub>si</sub> = 100	TPout (g/m <sup>3</sup> )	0.017
k <sub>1TP</sub> (m/y)	k <sub>1TP</sub> (m/y)	5.31
k <sub>sp</sub> = 0	W (m)	0.2205
k <sub>e</sub> = 0.000819	P <sub>w</sub> (g/m <sup>3</sup> )	0.0165
k <sub>a</sub> = 0.00245	B (g AFDW/m <sup>2</sup> )	103.8
k <sub>f</sub> = 0.0337	P <sub>B</sub> (g/m <sup>2</sup> )	0.1691
k <sub>u</sub> = 0.0034	P <sub>B</sub> /B (mg/kg AFDW)	1661.2
H = 0	b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	2.94
	b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	2.56

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

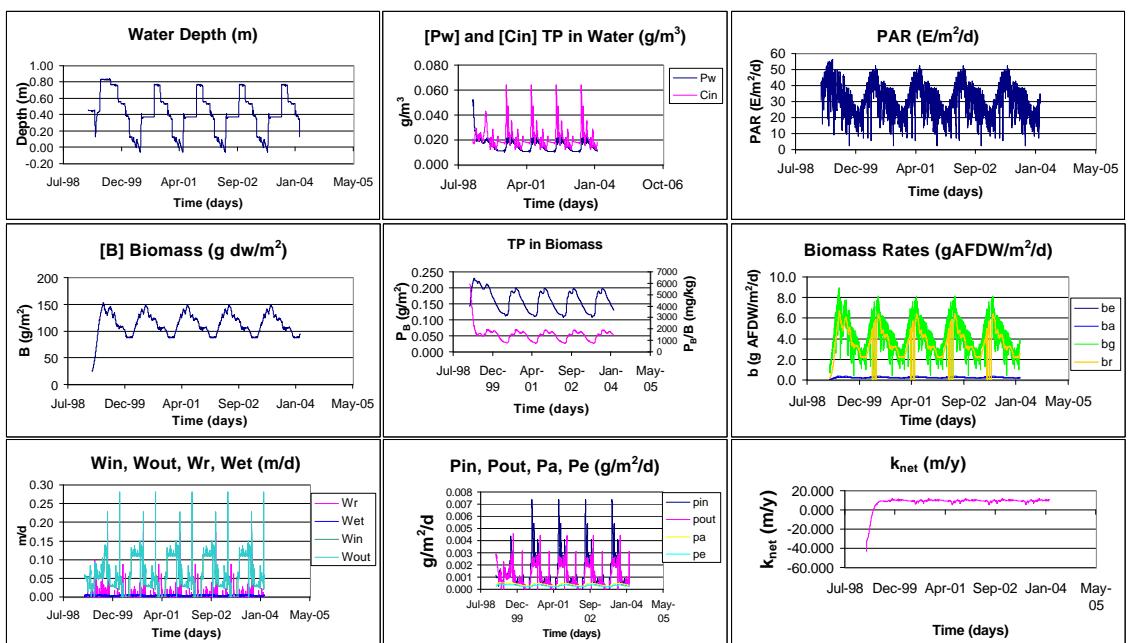
Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90e V-notch  
 Weir Width = 1 ft

CELL	TC 3
HLR (cm/d)	variable
DEPTH (ft)	variable

Note: User inputs in red



Adjustable Constants	Parameter	P.O.R Avg
k <sub>r</sub> = 0.000286	HLR (m/y)	20.68
k <sub>g</sub> = 0.165	TPin (g/m <sup>3</sup> )	0.021
k <sub>si</sub> = 100	TPout (g/m <sup>3</sup> )	0.016
k <sub>1TP</sub> (m/y)	k <sub>1TP</sub> (m/y)	6.61
k <sub>sp</sub> = 0	W (m)	0.4195
k <sub>e</sub> = 0.000819	P <sub>w</sub> (g/m <sup>3</sup> )	0.0155
k <sub>a</sub> = 0.00245	B (g AFDW/m <sup>2</sup> )	113.1
k <sub>f</sub> = 0.0337	P <sub>B</sub> (g/m <sup>2</sup> )	0.1607
k <sub>u</sub> = 0.0034	P <sub>B</sub> /B (mg/kg AFDW)	1501.3
H = 0.001	b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	4.0722
	b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.5507

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

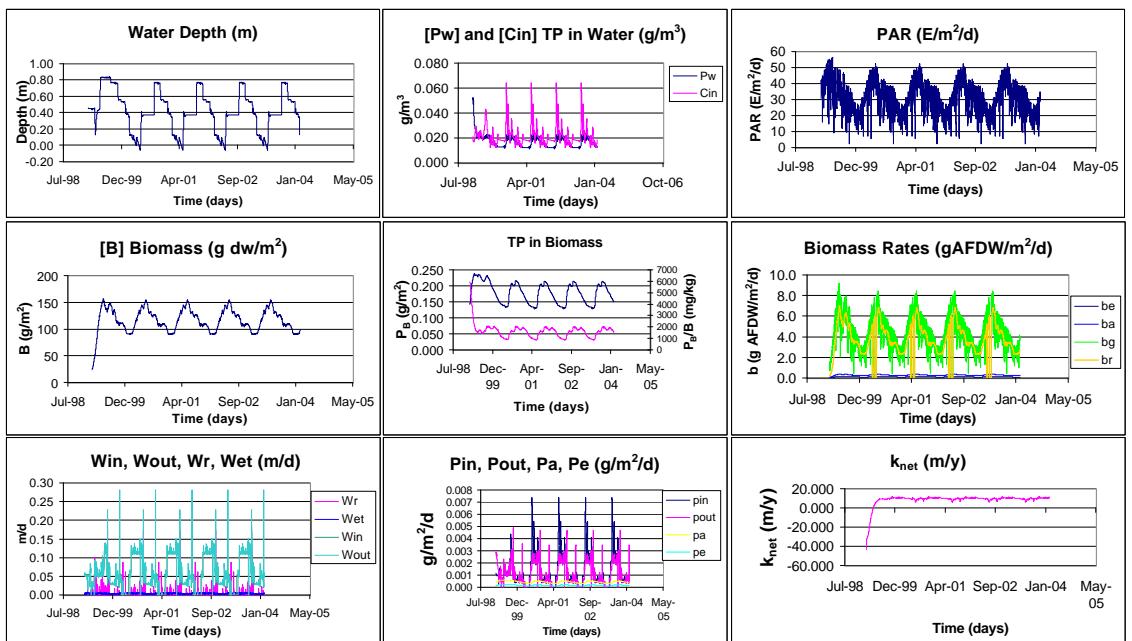
Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft

CELL	TC 3
HLR (cm/d)	variable
DEPTH (ft)	variable

Note: User inputs in red



Adjustable Constants	Parameter	P.O.R Avg
k <sub>r</sub> = 0.000286	HLR (m/y)	20.68
k <sub>g</sub> = 0.165	TPin (g/m <sup>3</sup> )	0.021
k <sub>si</sub> = 100	TPout (g/m <sup>3</sup> )	0.017
k <sub>1TP</sub> (m/y)	k <sub>1TP</sub> (m/y)	5.02
k <sub>sp</sub> = 0	W (m)	0.4195
k <sub>e</sub> = 0.000819	P <sub>w</sub> (g/m <sup>3</sup> )	0.0168
k <sub>a</sub> = 0.00245	B (g AFDW/m <sup>2</sup> )	116.38
k <sub>f</sub> = 0.0337	P <sub>B</sub> (g/m <sup>2</sup> )	0.1784
k <sub>u</sub> = 0.0034	P <sub>B</sub> /B (mg/kg AFDW)	1616.2
H = 0.0001	b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	4.1894
	b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.7568

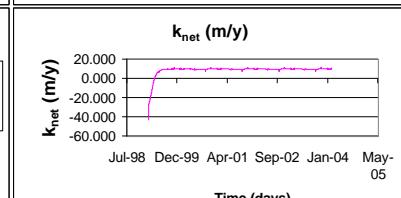
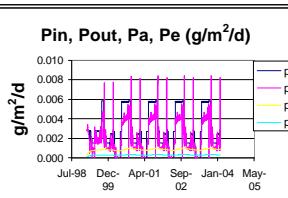
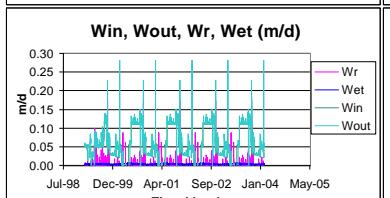
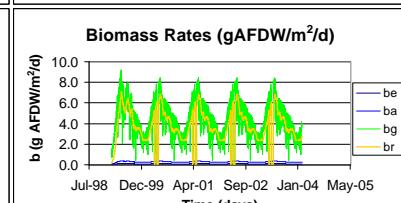
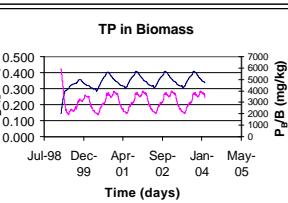
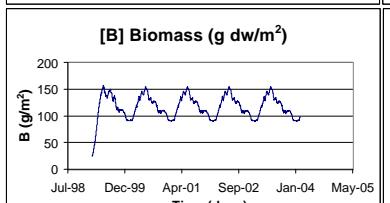
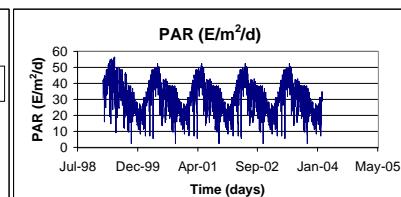
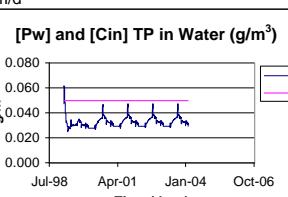
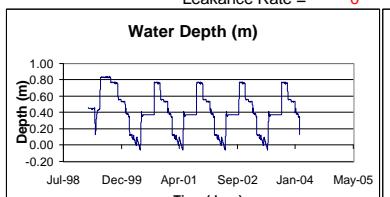
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 3
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.050
HLR (cm/d)	variable
DEPTH (ft)	variable



Parameter	P.O.R Avg
HLR (m/y)	20.68
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.032
k <sub>1TP</sub> (m/y)	8.97
W (m)	0.4195
P <sub>w</sub> (g/m <sup>3</sup> )	0.0324
B (g AFDW/m <sup>2</sup> )	116.75
P <sub>B</sub> (g/m <sup>2</sup> )	0.3431
P <sub>B</sub> /B (mg/kg AFDW)	3055
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	4.2024
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.7801
H =	0

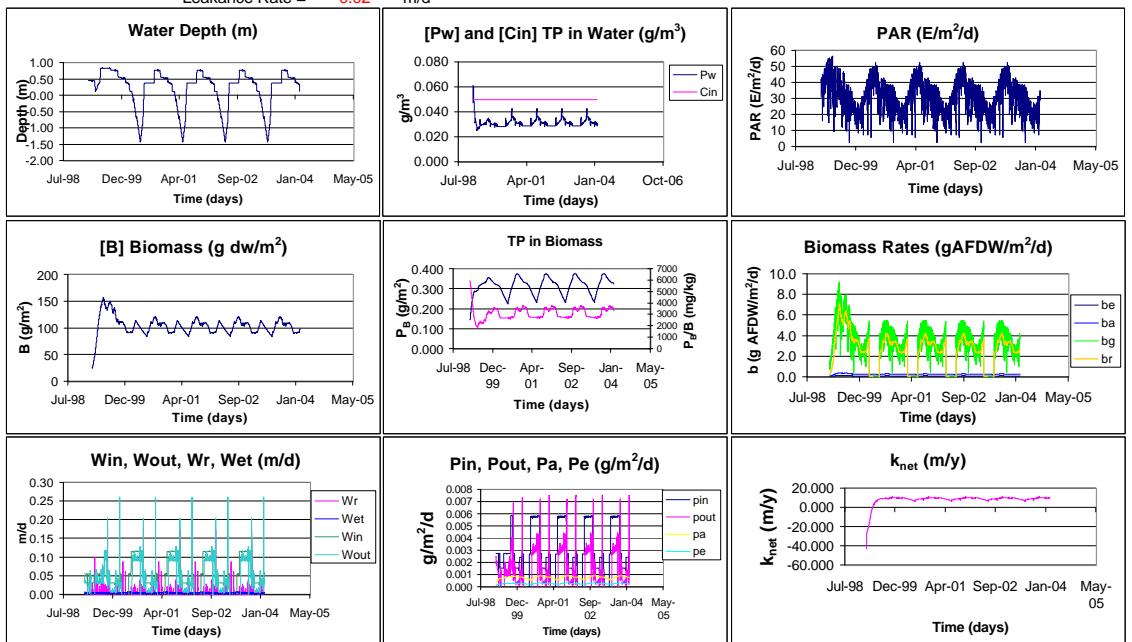
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0.02 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 3
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.050
HLR (cm/d)	variable
DEPTH (ft)	variable



Parameter	P.O.R Avg
HLR (m/y)	20.68
TP <sub>in</sub> (g/m <sup>3</sup> )	0.050
TP <sub>out</sub> (g/m <sup>3</sup> )	0.031
k <sub>1TP</sub> (m/y)	9.81
W (m)	0.2205
P <sub>w</sub> (g/m <sup>3</sup> )	0.0311
B (g AFDW/m <sup>2</sup> )	103.8
P <sub>B</sub> (g/m <sup>2</sup> )	0.3133
P <sub>B</sub> /B (mg/kg AFDW)	3071
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	2.94
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	2.56
H =	0

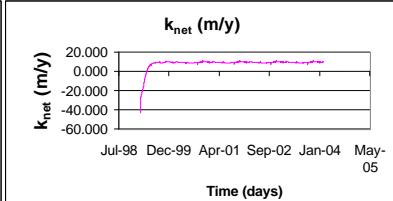
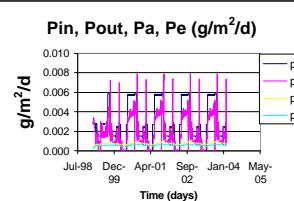
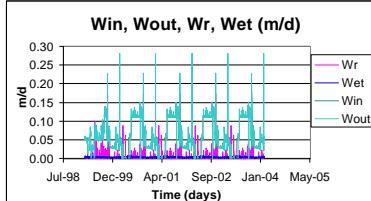
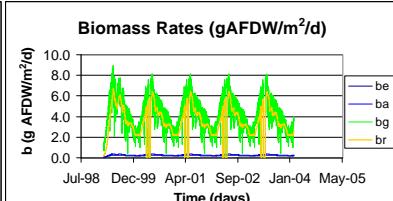
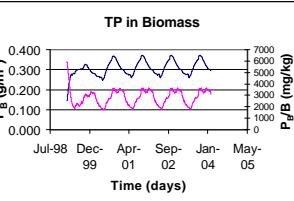
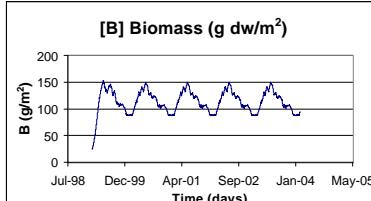
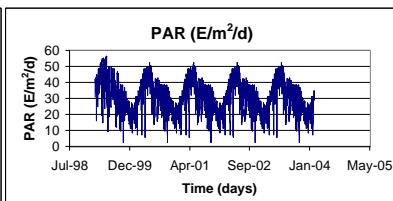
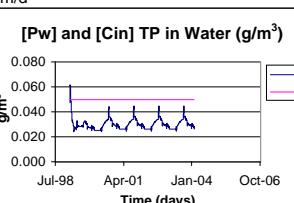
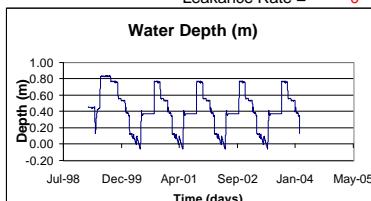
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 3
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.050
HLR (cm/d)	variable
DEPTH (ft)	variable



Parameter	P.O.R Avg
HLR (m/y)	20.68
TP <sub>in</sub> (g/m <sup>3</sup> )	0.050
TP <sub>out</sub> (g/m <sup>3</sup> )	0.030
k <sub>1TP</sub> (m/y)	10.67
W (m)	0.4195
P <sub>w</sub> (g/m <sup>3</sup> )	0.0298
B (g AFDW/m <sup>2</sup> )	113.1
P <sub>B</sub> (g/m <sup>2</sup> )	0.3064
P <sub>B</sub> /B (mg/kg AFDW)	2820.3
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	4.0722
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.5507
H =	0.001

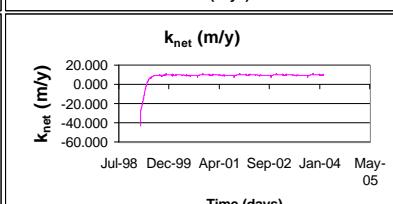
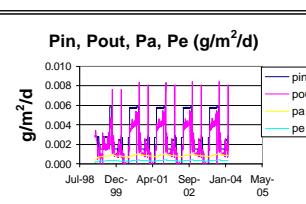
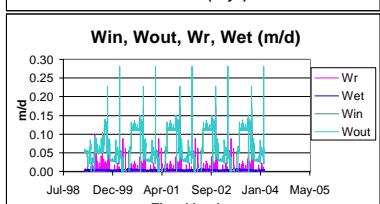
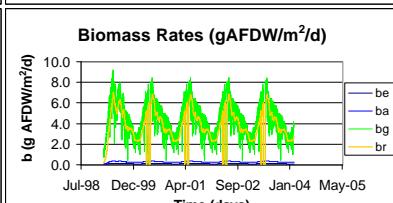
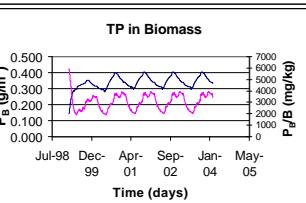
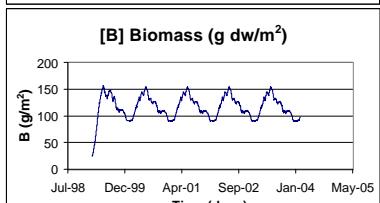
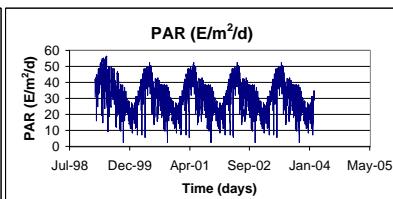
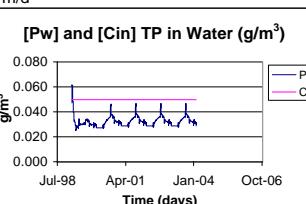
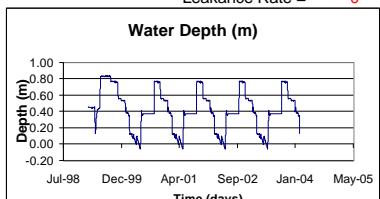
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 3
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.050
HLR (cm/d)	variable
DEPTH (ft)	variable



Parameter	P.O.R Avg
HLR (m/y)	20.68
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.032
k <sub>1TP</sub> (m/y)	9.15
W (m)	0.4195
P <sub>w</sub> (g/m <sup>3</sup> )	0.0321
B (g AFDW/m <sup>2</sup> )	116.38
P <sub>B</sub> (g/m <sup>2</sup> )	0.3391
P <sub>B</sub> /B (mg/kg AFDW)	3029.1
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	4.1894
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.7568
H =	0.0001

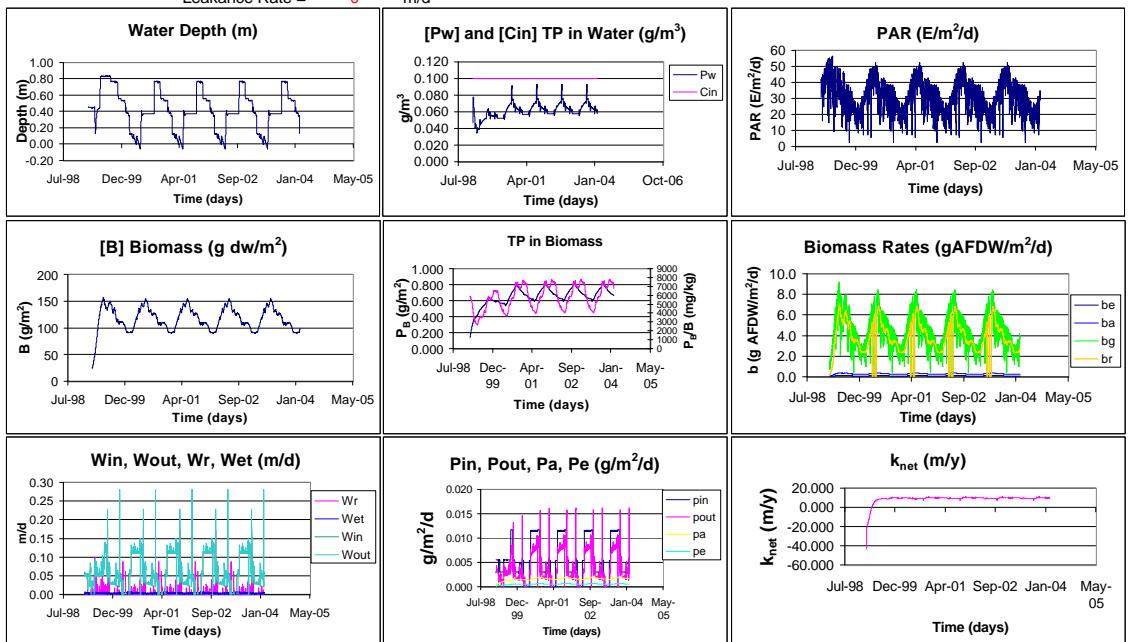
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 3
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	variable
DEPTH (ft)	variable



Parameter	P.O.R Avg
HLR (m/y)	20.68
TP <sub>in</sub> (g/m <sup>3</sup> )	0.100
TP <sub>out</sub> (g/m <sup>3</sup> )	0.061
k <sub>1TP</sub> (m/y)	10.10
W (m)	0.4195
P <sub>w</sub> (g/m <sup>3</sup> )	0.0614
B (g AFDW/m <sup>2</sup> )	116.75
P <sub>B</sub> (g/m <sup>2</sup> )	0.6498
P <sub>B</sub> /B (mg/kg AFDW)	5747
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	4.2024
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.7801
H =	0

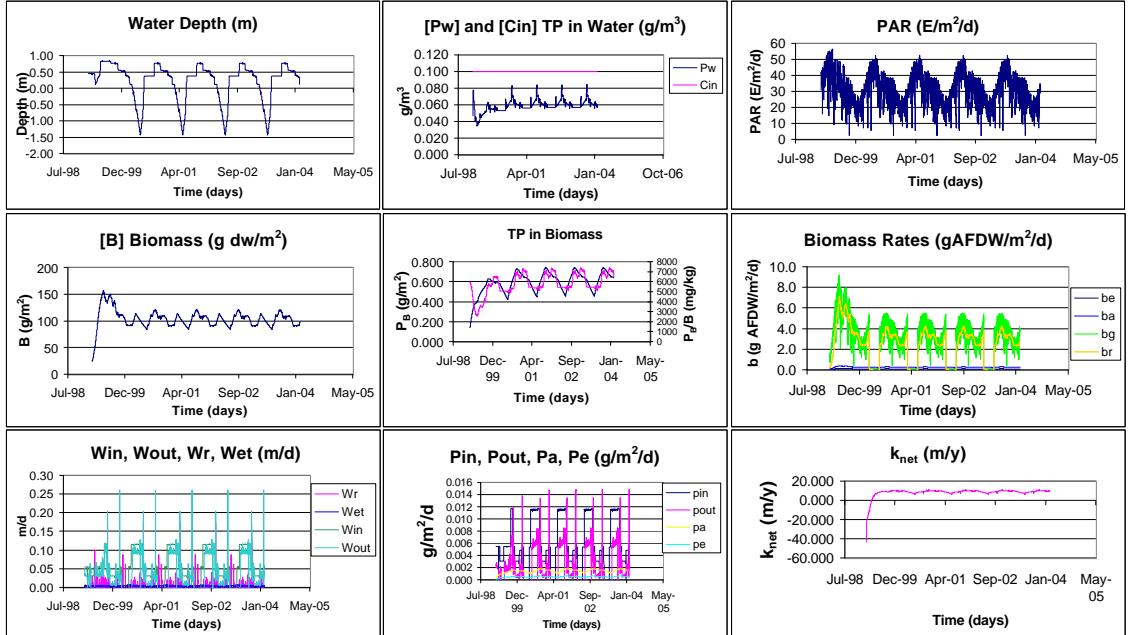
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0.02 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 3
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	variable
DEPTH (ft)	variable



Parameter	P.O.R Avg
HLR (m/y)	20.68
TP <sub>in</sub> (g/m <sup>3</sup> )	0.100
TP <sub>out</sub> (g/m <sup>3</sup> )	0.059
k <sub>1TP</sub> (m/y)	10.99
W (m)	0.2205
P <sub>w</sub> (g/m <sup>3</sup> )	0.0588
B (g AFDW/m <sup>2</sup> )	103.8
P <sub>B</sub> (g/m <sup>2</sup> )	0.5904
P <sub>B</sub> /B (mg/kg AFDW)	5767.9
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	2.94
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	2.56
H =	0

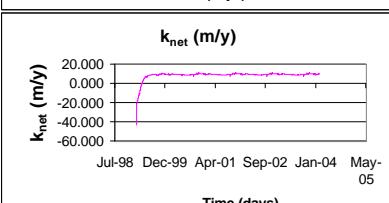
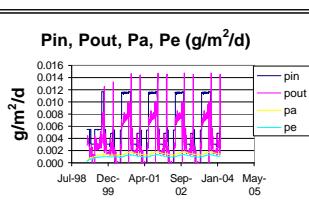
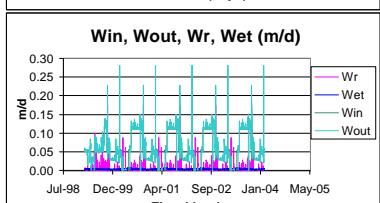
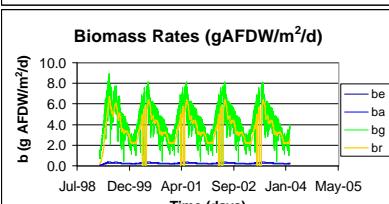
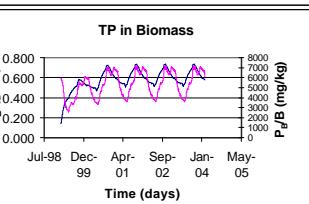
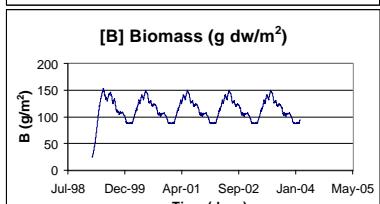
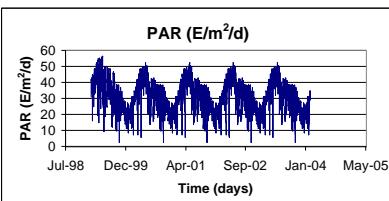
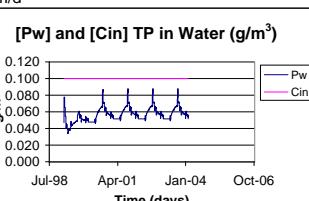
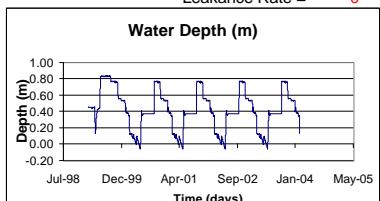
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 3
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	variable
DEPTH (ft)	variable



Parameter	P.O.R Avg
HLR (m/y)	20.68
TPin (g/m <sup>3</sup> )	0.100
TPout (g/m <sup>3</sup> )	0.057
k <sub>1TP</sub> (m/y)	11.78
W (m)	0.4195
P <sub>w</sub> (g/m <sup>3</sup> )	0.0566
B (g AFDW/m <sup>2</sup> )	113.1
P <sub>B</sub> (g/m <sup>2</sup> )	0.5806
P <sub>B</sub> /B (mg/kg AFDW)	5306.6
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	4.0722
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.5507
k <sub>r</sub>	0.000286
k <sub>g</sub>	0.165
k <sub>si</sub>	100
k <sub>sp</sub>	0
k <sub>e</sub>	0.000819
k <sub>a</sub>	0.00245
k <sub>i</sub>	0.0337
k <sub>u</sub>	0.0034
H	0.001

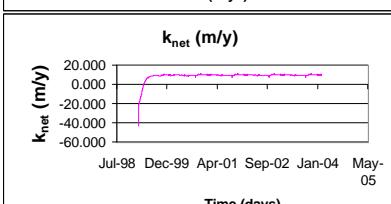
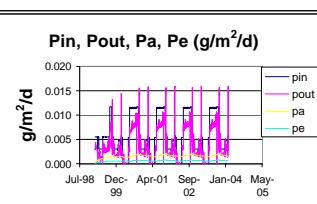
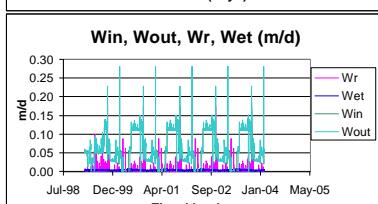
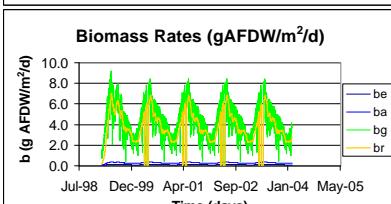
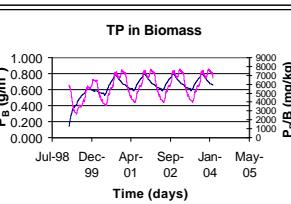
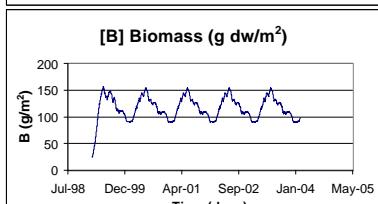
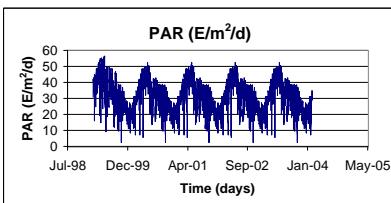
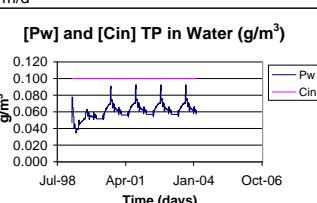
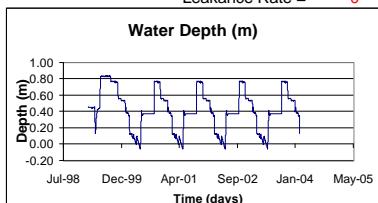
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.3 ft  
 Starting Stage = 15.8 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.047 g/m<sup>3</sup>  
 Initial B = 24.1 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1430 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1770 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 3
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	variable
DEPTH (ft)	variable



Parameter	P.O.R Avg
HLR (m/y)	20.68
TP <sub>in</sub> (g/m <sup>3</sup> )	0.100
TP <sub>out</sub> (g/m <sup>3</sup> )	0.061
k <sub>1TP</sub> (m/y)	10.28
W (m)	0.4195
P <sub>w</sub> (g/m <sup>3</sup> )	0.0608
B (g AFDW/m <sup>2</sup> )	116.38
P <sub>B</sub> (g/m <sup>2</sup> )	0.6422
P <sub>B</sub> /B (mg/kg AFDW)	5698.4
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	4.1894
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	3.7568
H =	0.0001

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

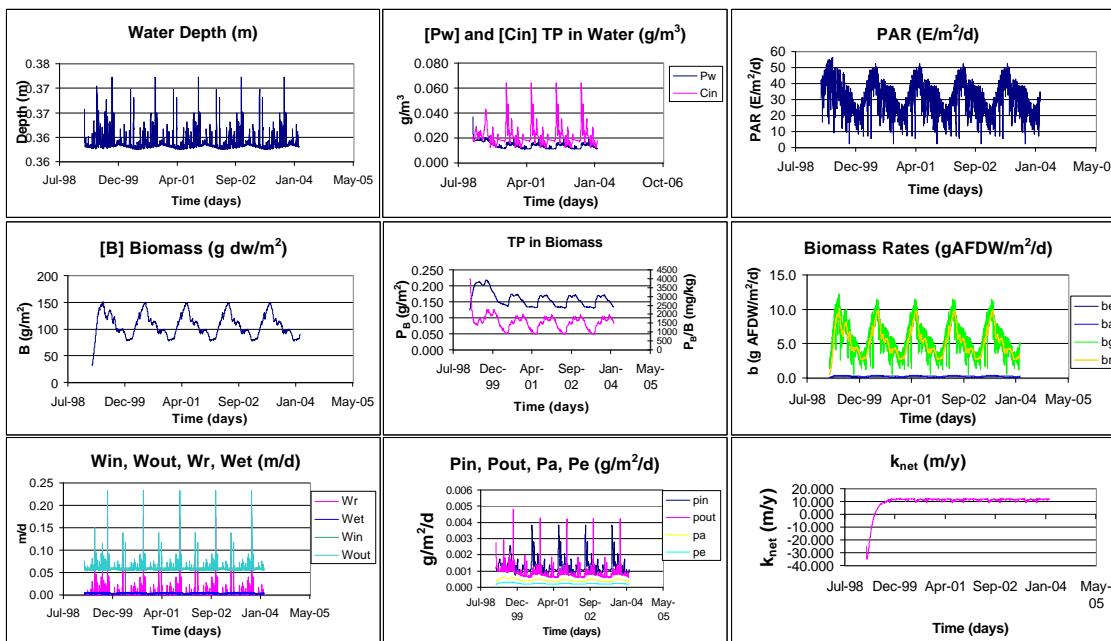
Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0** m/d

Initial P<sub>w</sub> = **0.037** g/m<sup>3</sup>  
 Initial B = **31.3** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.1250** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1510** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90e V-notch**  
 Weir Width = **1** ft

CELL **TC 8**  
 HLR (cm/d) **fixed 6.0**  
 DEPTH (ft) **fixed 1.0**

Note: User inputs in red



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.021
TPout (g/m <sup>3</sup> )	0.014
k <sub>1TP</sub> (m/y)	9.40
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0139
B (g AFDW/m <sup>2</sup> )	107.22
P <sub>B</sub> (g/m <sup>2</sup> )	0.159
P <sub>B</sub> /B (mg/kg AFDW)	1545.8
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.7489
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.2706
H =	0

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

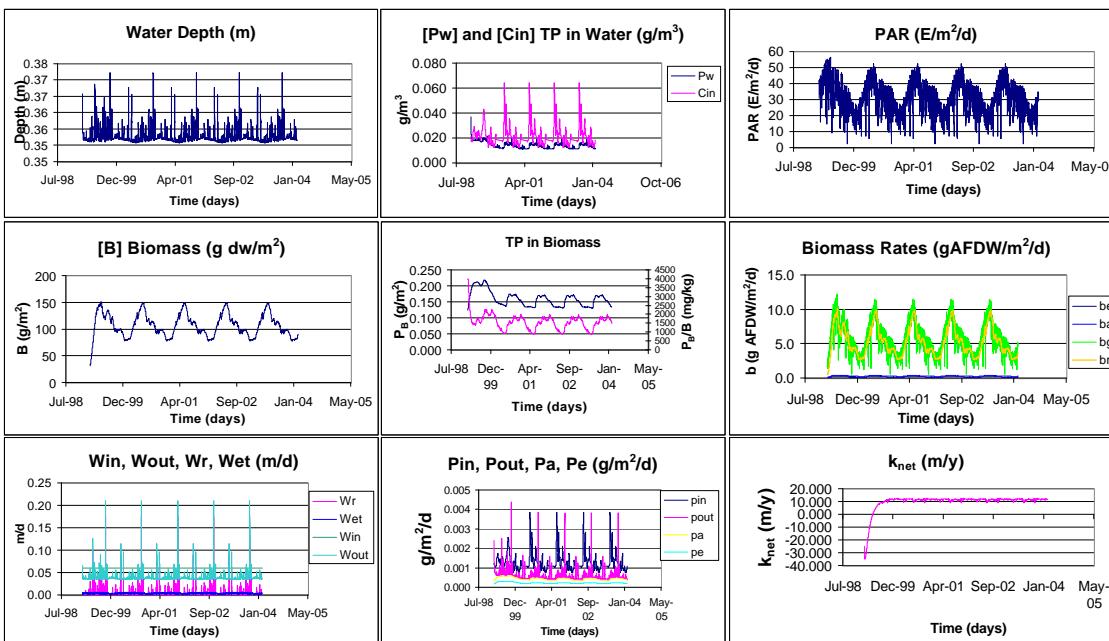
Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0.02 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90e V-notch  
 Weir Width = 1 ft

Note: User inputs in red

CELL	TC 8
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Adjustable Constants	Parameter	P.O.R Avg
k <sub>r</sub> = 0.000441	HLR (m/y)	21.90
k <sub>g</sub> = 0.227	TPin (g/m <sup>3</sup> )	0.021
k <sub>si</sub> = 100	TPout (g/m <sup>3</sup> )	0.014
k <sub>1TP</sub> (m/y)	k <sub>1TP</sub> (m/y)	9.41
k <sub>sp</sub> = 0	W (m)	0.3527
k <sub>e</sub> = 0.00141	P <sub>w</sub> (g/m <sup>3</sup> )	0.0139
k <sub>a</sub> = 0.00275	B (g AFDW/m <sup>2</sup> )	107.22
k <sub>f</sub> = 0.0189	P <sub>B</sub> (g/m <sup>2</sup> )	0.1589
k <sub>u</sub> = 0.0055	P <sub>B</sub> /B (mg/kg AFDW)	1545.6
H = 0	b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.7489
	b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.2706

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

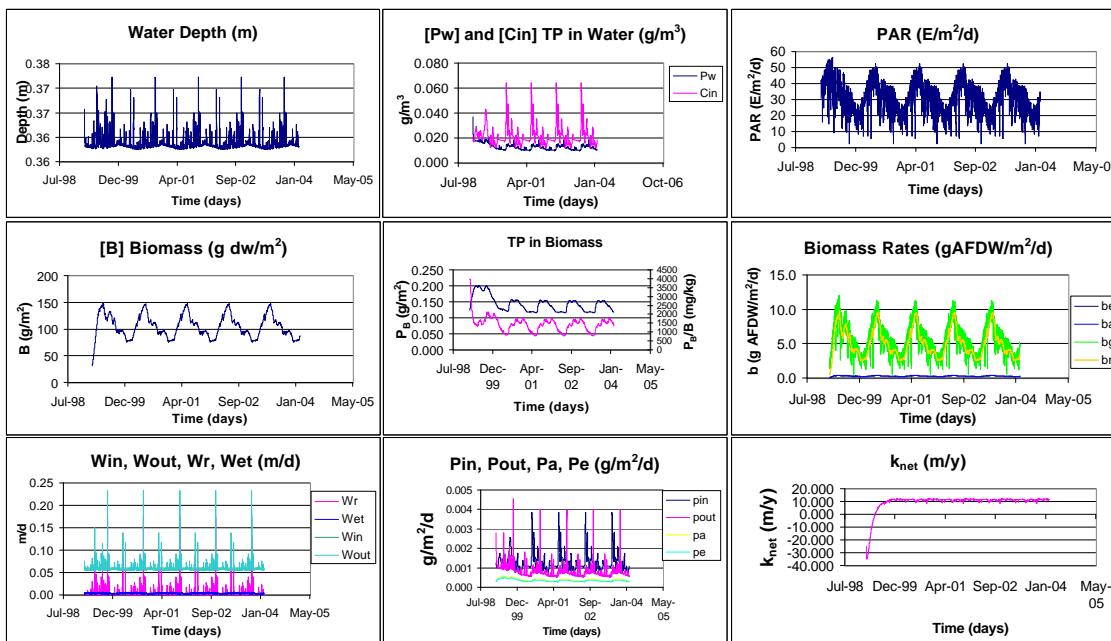
Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft

Note: User inputs in red

CELL	TC 8
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Adjustable Constants	Parameter	P.O.R Avg
k <sub>r</sub> = 0.000441	HLR (m/y)	21.90
k <sub>g</sub> = 0.227	TPin (g/m³)	0.021
k <sub>si</sub> = 100	TPout (g/m³)	0.013
k <sub>1TP</sub> (m/y)	k <sub>1TP</sub> (m/y)	11.26
k <sub>sp</sub> = 0	W (m)	0.3588
k <sub>e</sub> = 0.00141	P <sub>w</sub> (g/m³)	0.0128
k <sub>a</sub> = 0.00275	B (g AFDW/m²)	104.99
k <sub>f</sub> = 0.0189	P <sub>B</sub> (g/m²)	0.143
k <sub>u</sub> = 0.0055	P <sub>B</sub> /B (mg/kg AFDW)	1421.7
H = 0.001	b <sub>q</sub> (g AFDW/m²/d)	5.6317
	b <sub>r</sub> (g AFDW/m²/d)	5.059

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

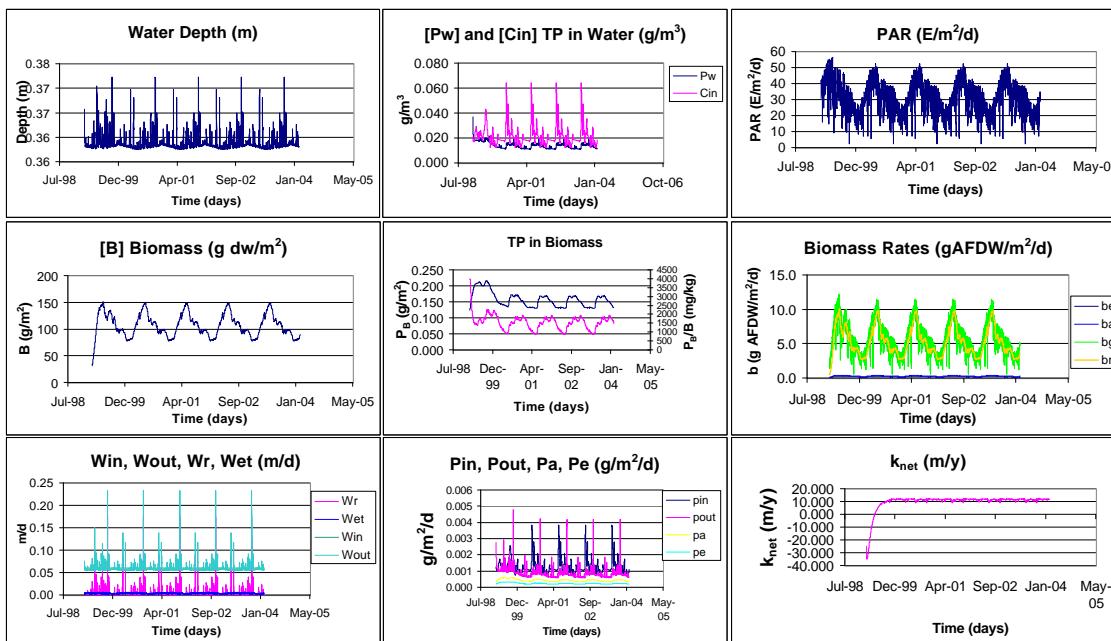
Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft

CELL TC 8  
 HLR (cm/d) fixed 6.0  
 DEPTH (ft) fixed 1.0

Note: User inputs in red



Adjustable Constants	Parameter	P.O.R Avg
k <sub>r</sub> = 0.000441	HLR (m/y)	21.90
k <sub>g</sub> = 0.227	TPin (g/m <sup>3</sup> )	0.021
k <sub>si</sub> = 100	TPout (g/m <sup>3</sup> )	0.014
k <sub>1TP</sub> (m/y)	k <sub>1TP</sub> (m/y)	9.60
k <sub>sp</sub> = 0	W (m)	0.3588
k <sub>e</sub> = 0.00141	P <sub>w</sub> (g/m <sup>3</sup> )	0.0138
k <sub>a</sub> = 0.00275	B (g AFDW/m <sup>2</sup> )	107
k <sub>f</sub> = 0.0189	P <sub>B</sub> (g/m <sup>2</sup> )	0.1572
k <sub>u</sub> = 0.0055	P <sub>B</sub> /B (mg/kg AFDW)	1532.1
H = 0.0001	b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.7372
	b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.2492

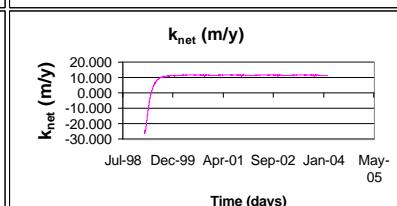
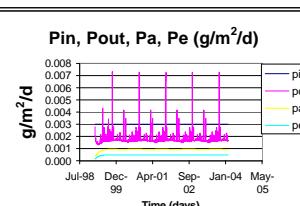
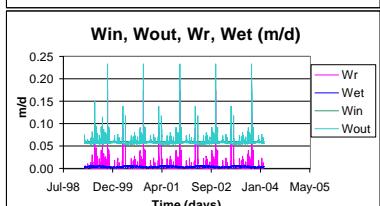
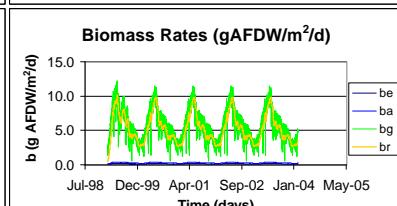
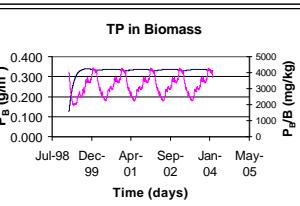
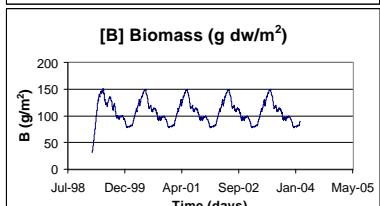
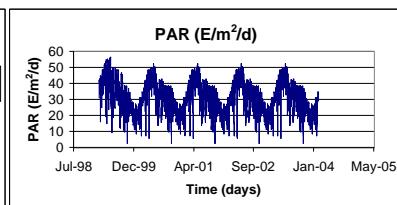
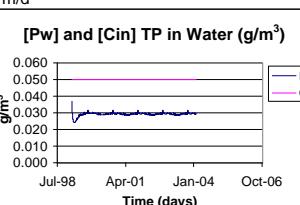
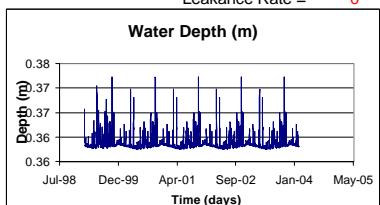
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL TC 8  
 TP<sub>in</sub> (g/m<sup>3</sup>) fixed 0.050  
 HLR (cm/d) fixed 6.0  
 DEPTH (ft) fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.029
k <sub>1TP</sub> (m/y)	11.88
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0291
B (g AFDW/m <sup>2</sup> )	107.22
P <sub>B</sub> (g/m <sup>2</sup> )	0.3292
P <sub>B</sub> /B (mg/kg AFDW)	3181.8
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.7489
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.2706
H =	0

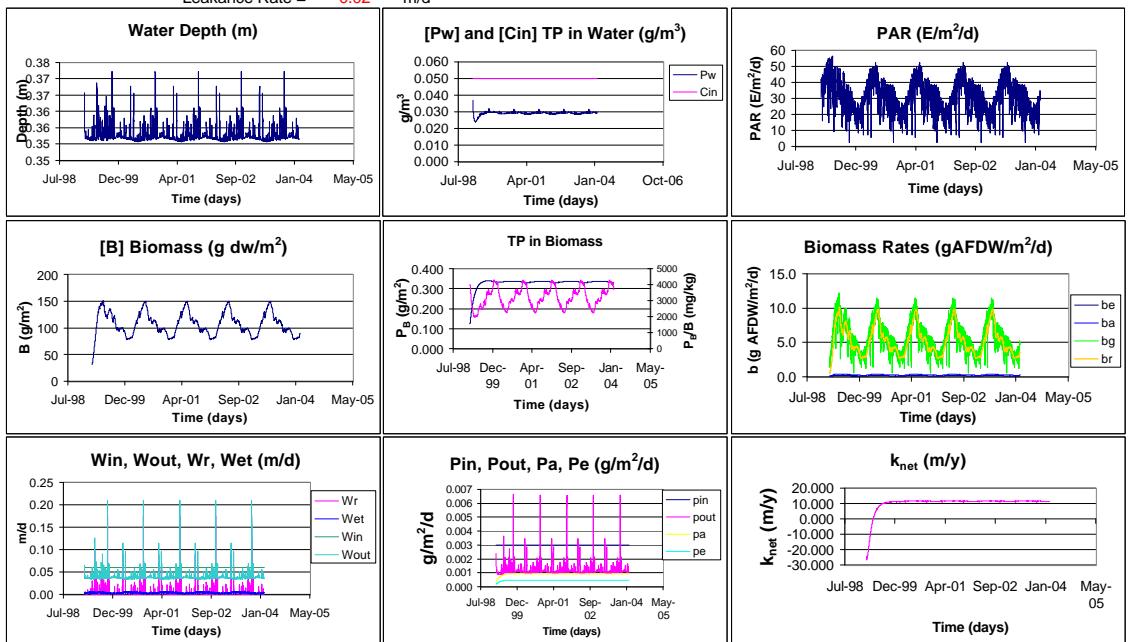
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
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 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0.02 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL TC 8  
 TP<sub>in</sub> (g/m<sup>3</sup>) fixed 0.050  
 HLR (cm/d) fixed 6.0  
 DEPTH (ft) fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.029
k <sub>1TP</sub> (m/y)	11.88
W (m)	0.3527
P <sub>w</sub> (g/m <sup>3</sup> )	0.0291
B (g AFDW/m <sup>2</sup> )	107.22
P <sub>B</sub> (g/m <sup>2</sup> )	0.3292
P <sub>B</sub> /B (mg/kg AFDW)	3181.6
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.7489
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.2706
H =	0

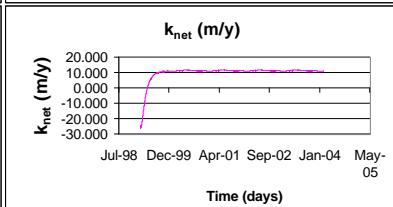
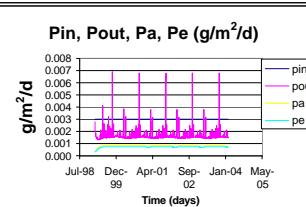
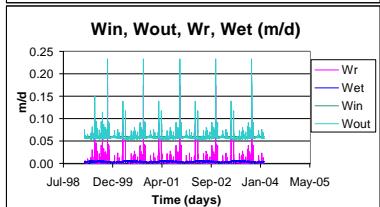
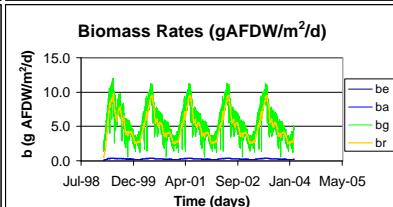
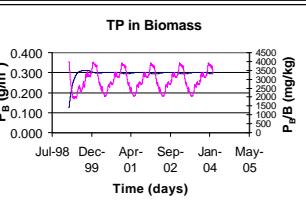
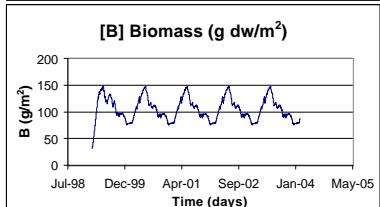
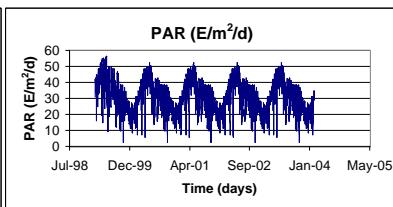
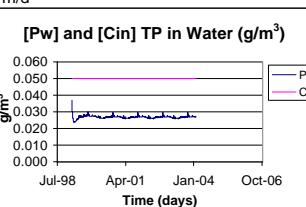
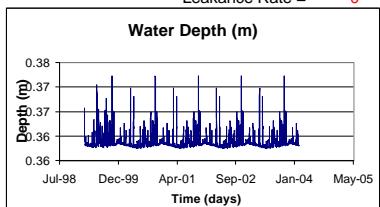
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL TC 8  
 TP<sub>in</sub> (g/m<sup>3</sup>) fixed 0.050  
 HLR (cm/d) fixed 6.0  
 DEPTH (ft) fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.027
k <sub>1TP</sub> (m/y)	13.72
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0267
B (g AFDW/m <sup>2</sup> )	104.99
P <sub>B</sub> (g/m <sup>2</sup> )	0.2962
P <sub>B</sub> /B (mg/kg AFDW)	2927.1
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.6317
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.059
k <sub>r</sub>	0.000441
k <sub>g</sub>	0.227
k <sub>si</sub>	100
k <sub>sp</sub>	0
k <sub>e</sub>	0.00141
k <sub>a</sub>	0.00275
k <sub>i</sub>	0.0189
k <sub>u</sub>	0.0055
H	0.001

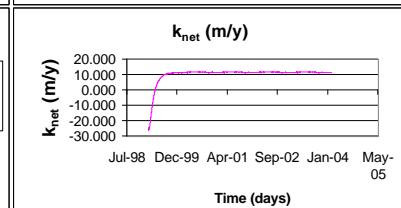
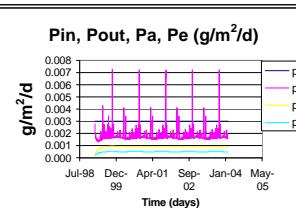
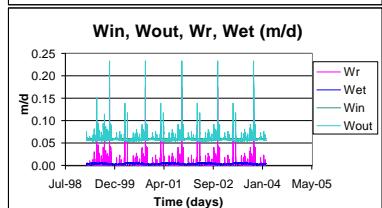
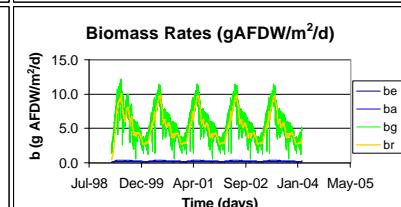
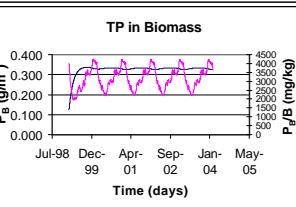
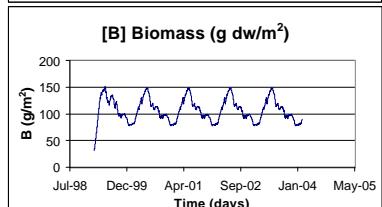
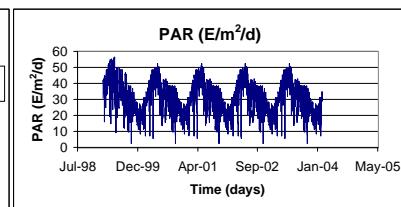
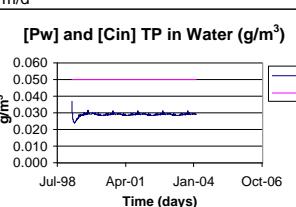
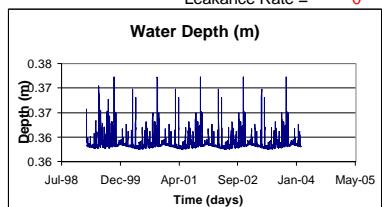
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL TC 8  
 TP<sub>in</sub> (g/m<sup>3</sup>) fixed 0.050  
 HLR (cm/d) fixed 6.0  
 DEPTH (ft) fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.029
k <sub>1TP</sub> (m/y)	12.08
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0288
B (g AFDW/m <sup>2</sup> )	107
P <sub>B</sub> (g/m <sup>2</sup> )	0.3256
P <sub>B</sub> /B (mg/kg AFDW)	3153.7
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.7372
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.2492
H =	0.0001

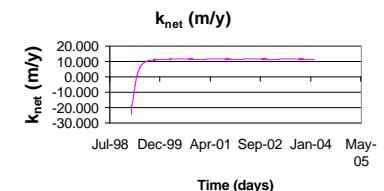
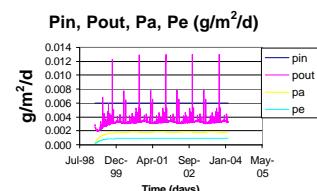
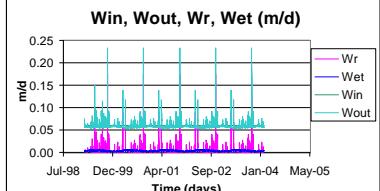
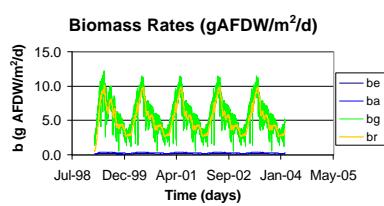
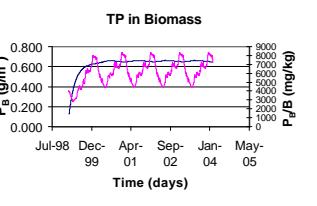
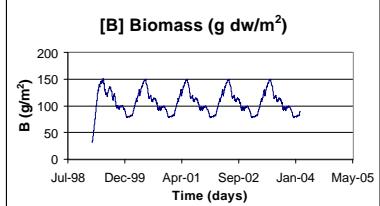
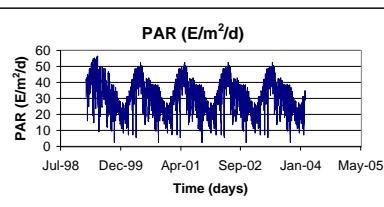
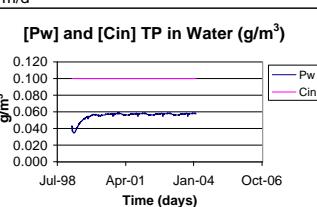
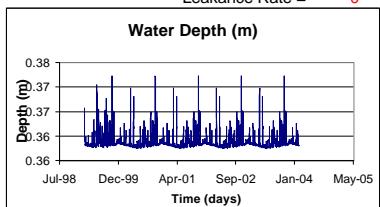
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**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL TC 8  
 TP<sub>in</sub> (g/m<sup>3</sup>) fixed 0.100  
 HLR (cm/d) fixed 6.0  
 DEPTH (ft) fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.100
TPout (g/m <sup>3</sup> )	0.056
k <sub>1TP</sub> (m/y)	12.87
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0556
B (g AFDW/m <sup>2</sup> )	107.22
P <sub>B</sub> (g/m <sup>2</sup> )	0.6284
P <sub>B</sub> /B (mg/kg AFDW)	6066.8
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.7489
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.2706
H =	0

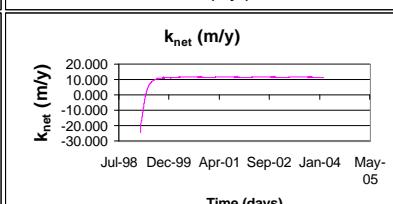
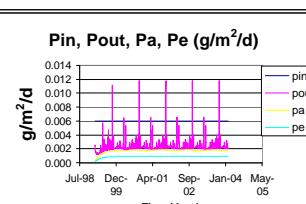
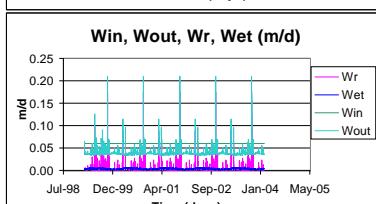
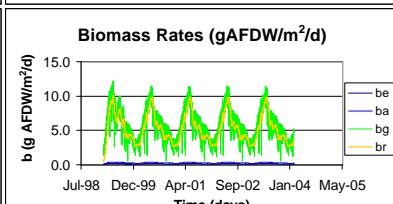
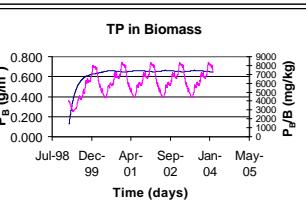
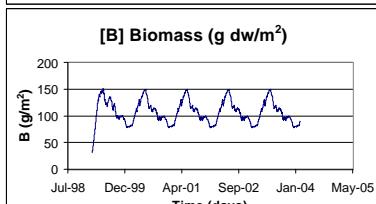
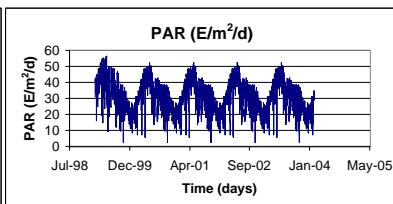
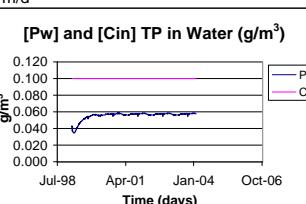
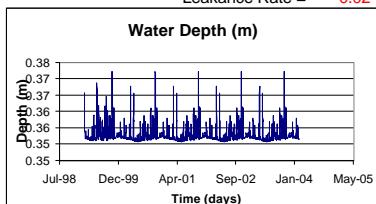
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0.02 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 8
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.100
TPout (g/m <sup>3</sup> )	0.056
k <sub>1TP</sub> (m/y)	12.87
W (m)	0.3527
P <sub>w</sub> (g/m <sup>3</sup> )	0.0556
B (g AFDW/m <sup>2</sup> )	107.22
P <sub>B</sub> (g/m <sup>2</sup> )	0.6284
P <sub>B</sub> /B (mg/kg AFDW)	6066.7
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.7489
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.2706
H = 0	

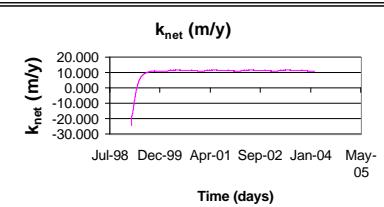
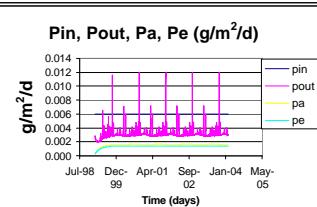
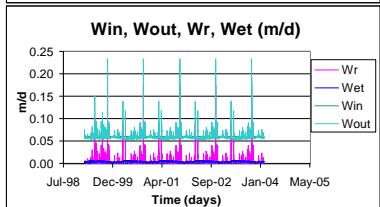
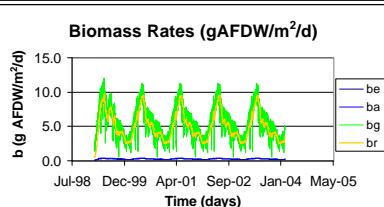
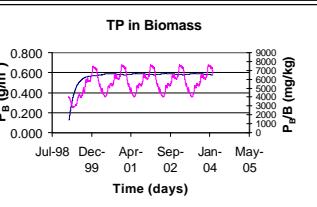
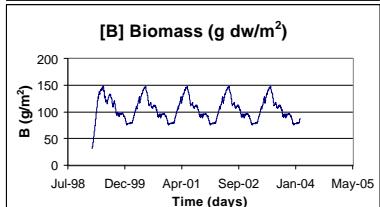
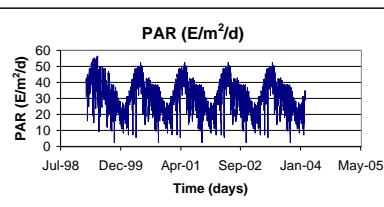
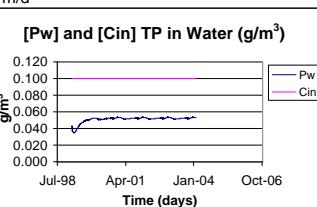
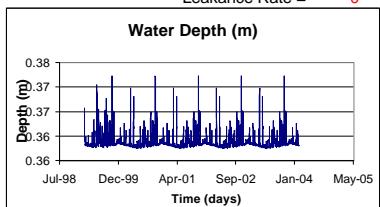
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 8
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.100
TPout (g/m <sup>3</sup> )	0.051
k <sub>1TP</sub> (m/y)	14.70
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0511
B (g AFDW/m <sup>2</sup> )	104.99
P <sub>B</sub> (g/m <sup>2</sup> )	0.5655
P <sub>B</sub> /B (mg/kg AFDW)	5581.5
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.6317
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.059
k <sub>r</sub>	0.000441
k <sub>g</sub>	0.227
k <sub>si</sub>	100
k <sub>sp</sub>	0
k <sub>e</sub>	0.00141
k <sub>a</sub>	0.00275
k <sub>i</sub>	0.0189
k <sub>u</sub>	0.0055
H	0.001

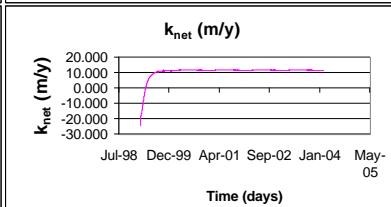
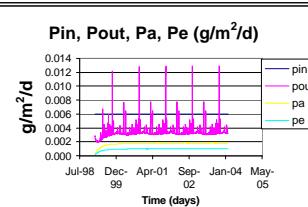
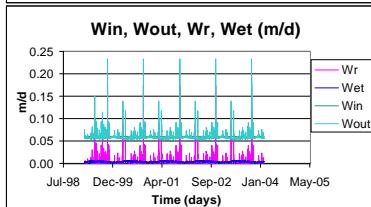
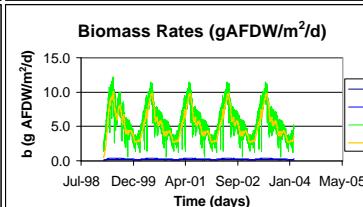
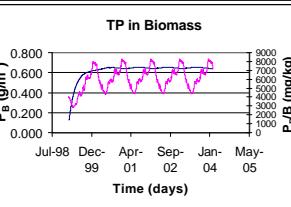
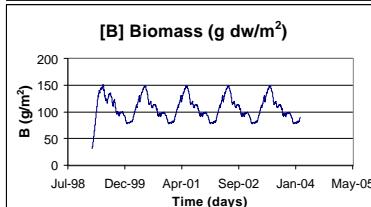
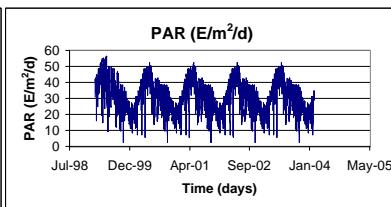
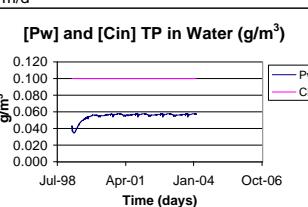
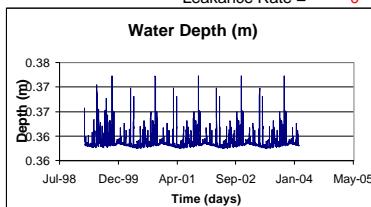
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.037 g/m<sup>3</sup>  
 Initial B = 31.3 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.1250 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1510 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL TC 8  
 TP<sub>in</sub> (g/m<sup>3</sup>) fixed 0.100  
 HLR (cm/d) fixed 6.0  
 DEPTH (ft) fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.100
TPout (g/m <sup>3</sup> )	0.055
k <sub>1TP</sub> (m/y)	13.06
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0551
B (g AFDW/m <sup>2</sup> )	107
P <sub>B</sub> (g/m <sup>2</sup> )	0.6215
P <sub>B</sub> /B (mg/kg AFDW)	6013.4
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	5.7372
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.2492
H =	0.0001

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

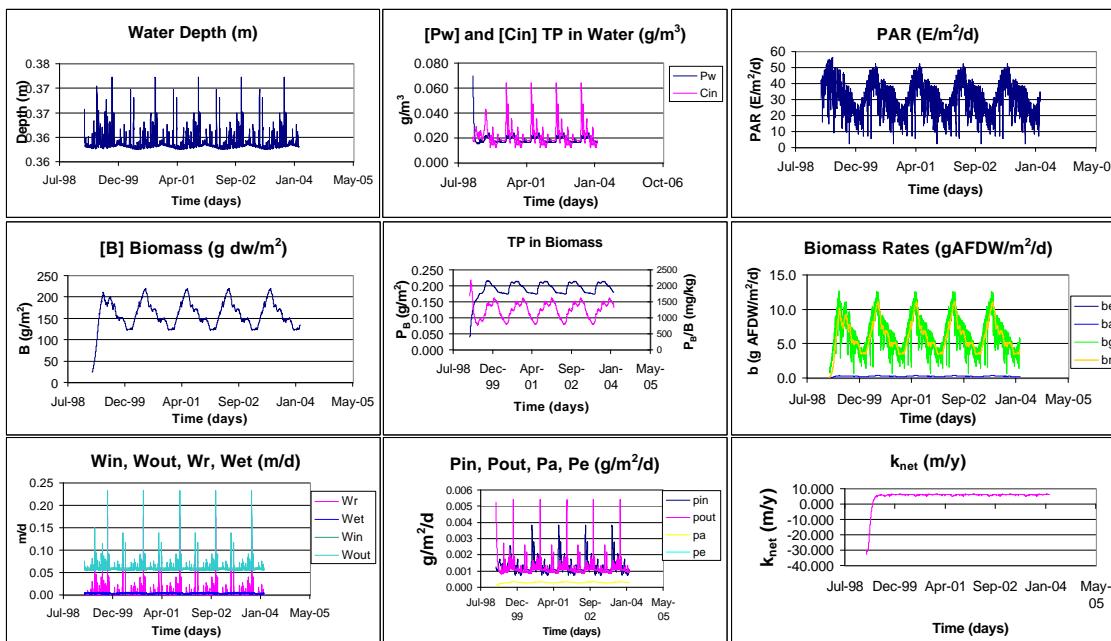
Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0 m/d

Initial P<sub>w</sub> = 0.07 g/m<sup>3</sup>  
 Initial B = 23.8 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.0400 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1200 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft

Note: User inputs in red

CELL	TC 13
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.021
TPout (g/m <sup>3</sup> )	0.019
k <sub>1TP</sub> (m/y)	3.05
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0186
B (g AFDW/m <sup>2</sup> )	159.38
P <sub>B</sub> (g/m <sup>2</sup> )	0.1899
P <sub>B</sub> /B (mg/kg AFDW)	1240.4
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.3875
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	6.0746
H =	0

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

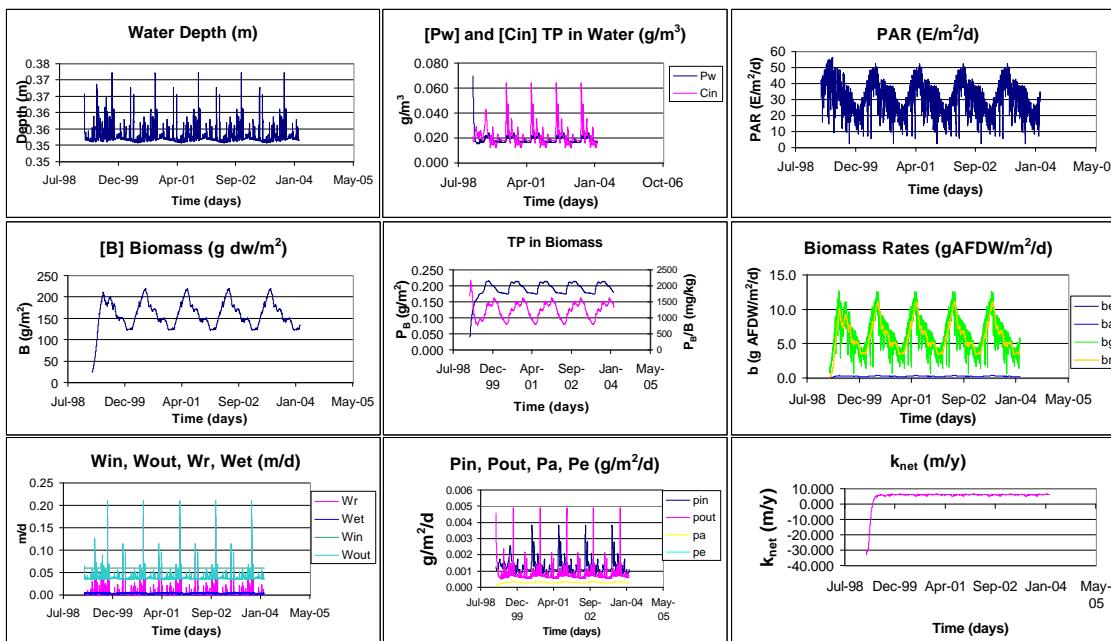
Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0.02** m/d

Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Initial B = **23.8** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90e V-notch**  
 Weir Width = **1** ft

CELL **TC 13**  
 HLR (cm/d) **fixed 6.0**  
 DEPTH (ft) **fixed 1.0**

Note: User inputs in red



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.021
TPout (g/m <sup>3</sup> )	0.019
k <sub>1TP</sub> (m/y)	3.06
W (m)	0.3527
P <sub>w</sub> (g/m <sup>3</sup> )	0.0186
B (g AFDW/m <sup>2</sup> )	159.38
P <sub>B</sub> (g/m <sup>2</sup> )	0.1898
P <sub>B</sub> /B (mg/kg AFDW)	1239.9
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.3875
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	6.0746
H =	0

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

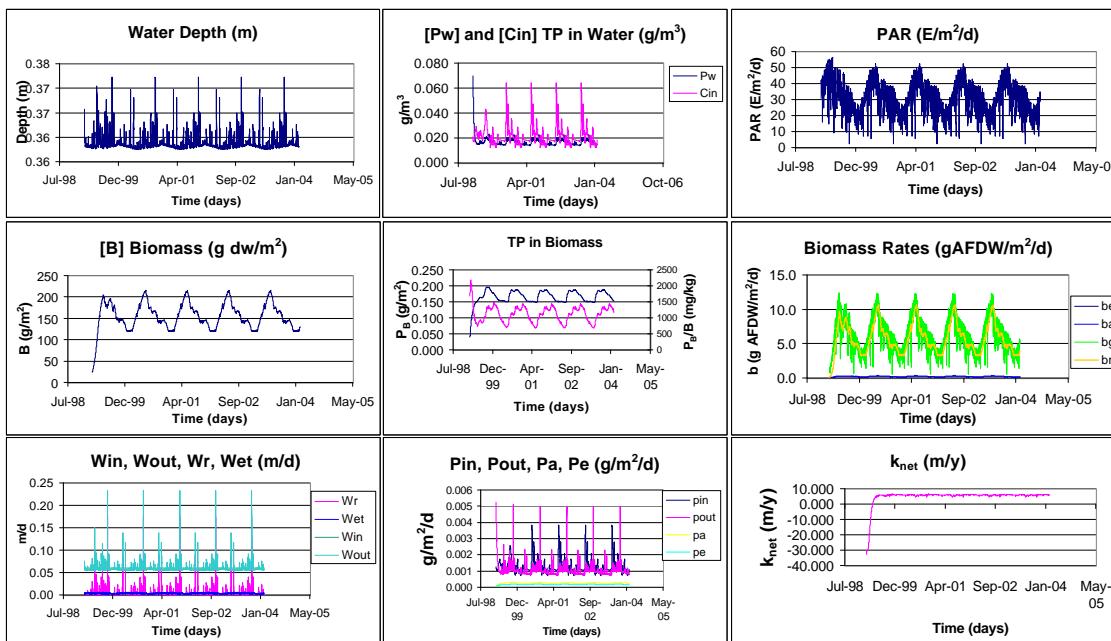
Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0** m/d

Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Initial B = **23.8** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90e V-notch**  
 Weir Width = **1** ft

CELL **TC 13**  
 HLR (cm/d) **fixed 6.0**  
 DEPTH (ft) **fixed 1.0**

Note: User inputs in red



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.021
TPout (g/m <sup>3</sup> )	0.017
k <sub>1TP</sub> (m/y)	5.40
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0167
B (g AFDW/m <sup>2</sup> )	155.12
P <sub>B</sub> (g/m <sup>2</sup> )	0.1657
P <sub>B</sub> /B (mg/kg AFDW)	1115.7
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.2187
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.76
H =	0.001
k <sub>r</sub> =	0.00023
k <sub>g</sub> =	0.171
k <sub>si</sub> =	100
k <sub>sp</sub> =	0
k <sub>e</sub> =	0
k <sub>a</sub> =	0.00158
k <sub>f</sub> =	0.0519
k <sub>u</sub> =	0.00252

**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

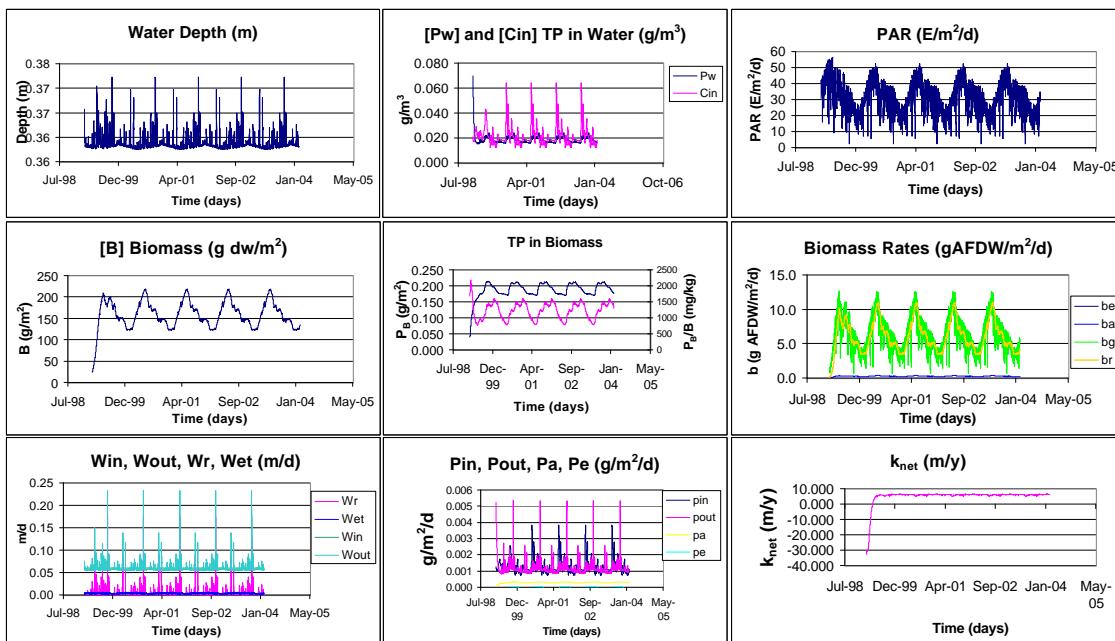
Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0** m/d

Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Initial B = **23.8** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90e V-notch**  
 Weir Width = **1** ft

Note: User inputs in red

CELL	TC 13
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.021
TPout (g/m <sup>3</sup> )	0.018
k <sub>1TP</sub> (m/y)	3.31
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0184
B (g AFDW/m <sup>2</sup> )	158.96
P <sub>B</sub> (g/m <sup>2</sup> )	0.1872
P <sub>B</sub> /B (mg/kg AFDW)	1226.3
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.3706
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	6.0427
H =	0.0001

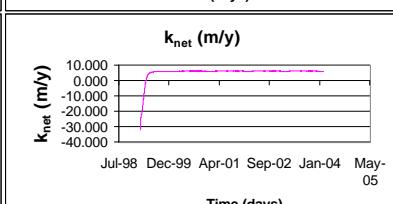
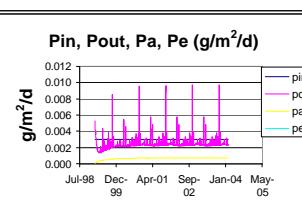
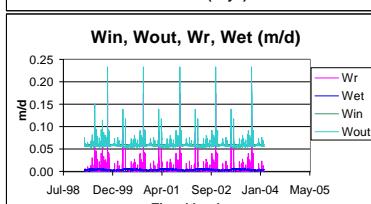
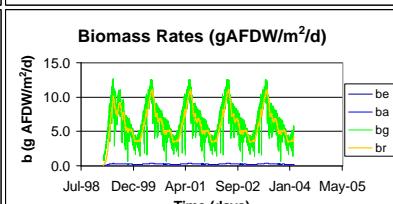
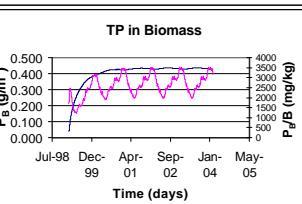
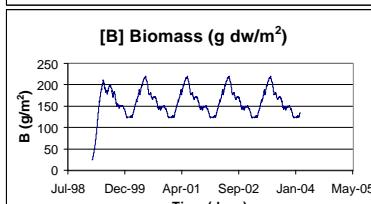
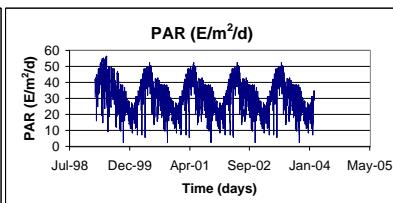
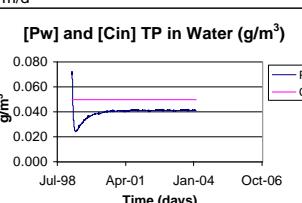
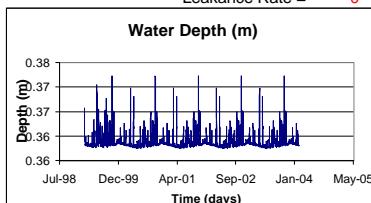
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0** m/d

Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Initial B = **23.8** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90o V-notch**  
 Weir Width = **1** ft  
 Note: User inputs in red

CELL	TC 13
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.050
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.039
k <sub>1TP</sub> (m/y)	5.16
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0395
B (g AFDW/m <sup>2</sup> )	159.38
P <sub>B</sub> (g/m <sup>2</sup> )	0.4036
P <sub>B</sub> /B (mg/kg AFDW)	2602.6
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.3875
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	6.0746
H =	0

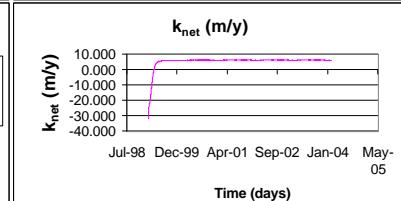
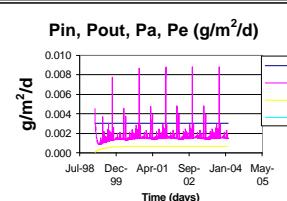
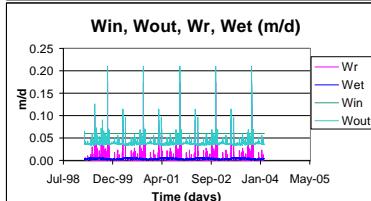
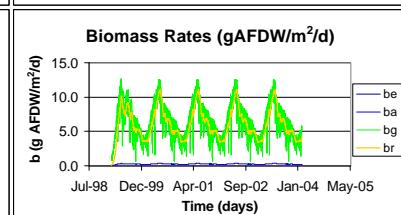
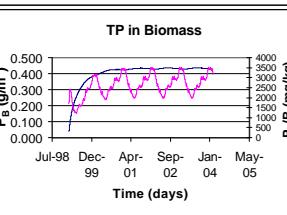
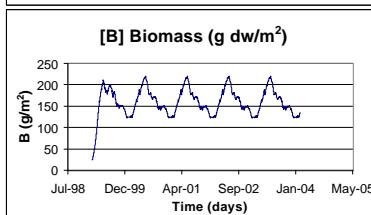
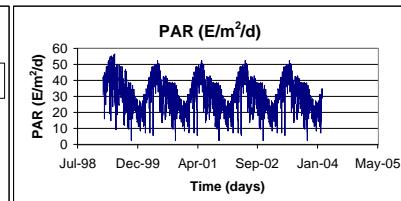
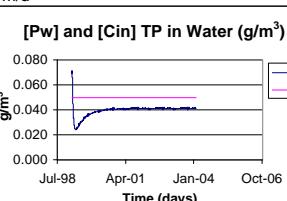
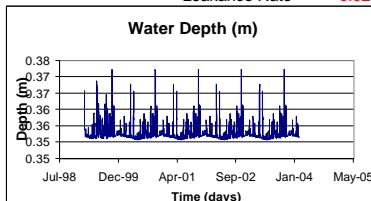
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0.02 m/d

Initial P<sub>w</sub> = 0.07 g/m<sup>3</sup>  
 Initial B = 23.8 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.0400 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1200 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 13
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.050
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.039
k <sub>1TP</sub> (m/y)	5.17
W (m)	0.3527
P <sub>w</sub> (g/m <sup>3</sup> )	0.0395
B (g AFDW/m <sup>2</sup> )	159.38
P <sub>B</sub> (g/m <sup>2</sup> )	0.4035
P <sub>B</sub> /B (mg/kg AFDW)	2602.2
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.3875
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	6.0746
H =	0

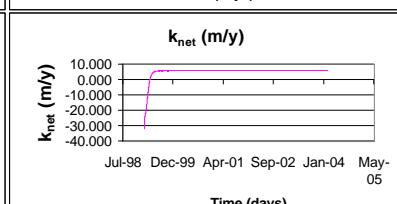
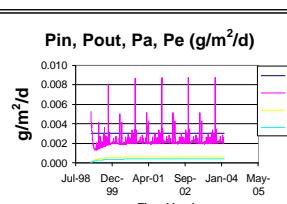
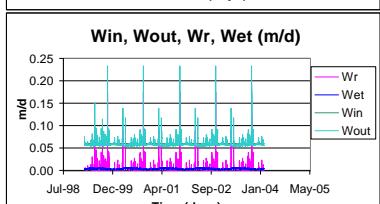
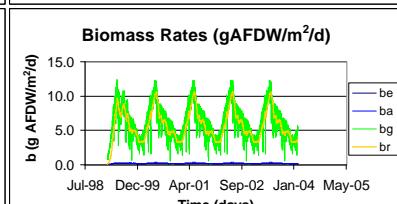
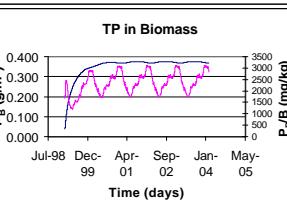
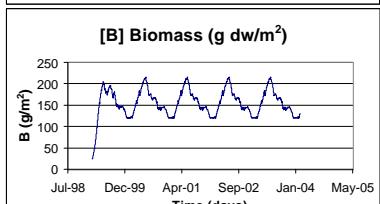
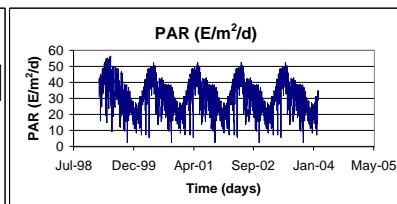
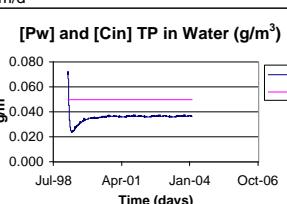
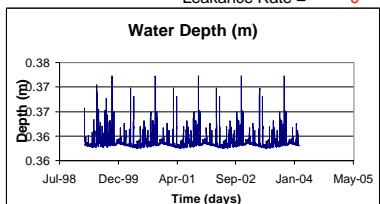
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0** m/d

Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Initial B = **23.8** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90o V-notch**  
 Weir Width = **1** ft  
 Note: User inputs in red

CELL	TC 13
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.050
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.035
k <sub>1TP</sub> (m/y)	7.50
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0355
B (g AFDW/m <sup>2</sup> )	155.12
P <sub>B</sub> (g/m <sup>2</sup> )	0.3523
P <sub>B</sub> /B (mg/kg AFDW)	2339.4
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.2187
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.76
H =	0.001

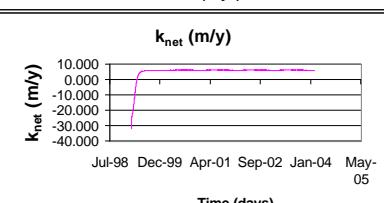
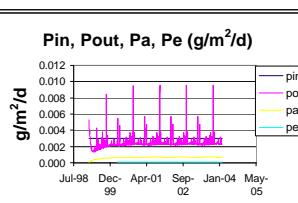
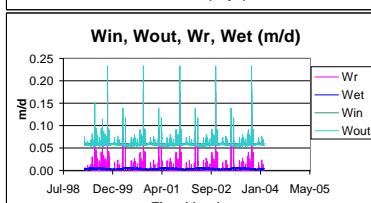
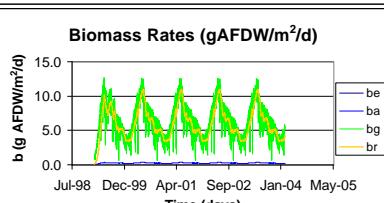
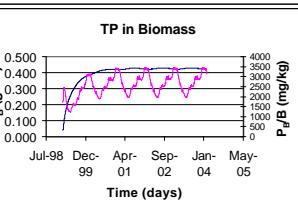
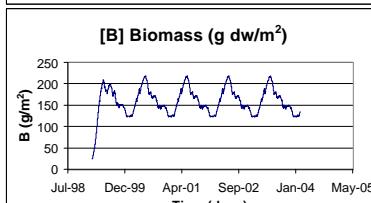
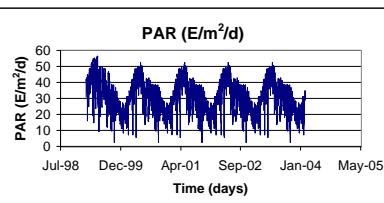
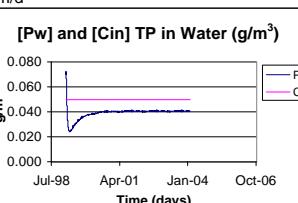
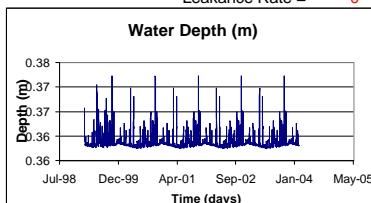
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0** m/d

Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Initial B = **23.8** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90o V-notch**  
 Weir Width = **1** ft  
 Note: User inputs in red

CELL	TC 13
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.050
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.050
TPout (g/m <sup>3</sup> )	0.039
k <sub>1TP</sub> (m/y)	5.42
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.039
B (g AFDW/m <sup>2</sup> )	158.96
P <sub>B</sub> (g/m <sup>2</sup> )	0.3978
P <sub>B</sub> /B (mg/kg AFDW)	2572.9
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.3706
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	6.0427
H =	0.0001

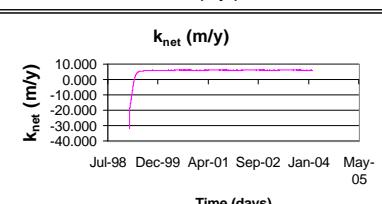
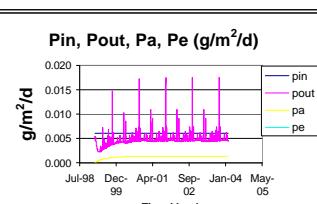
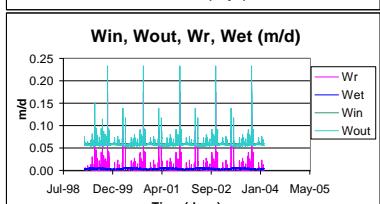
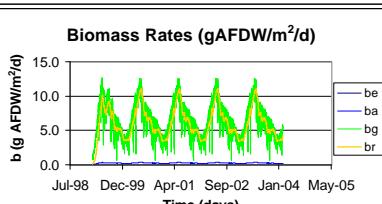
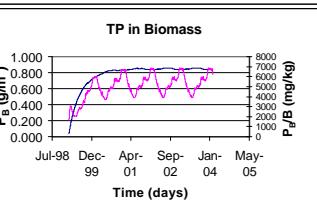
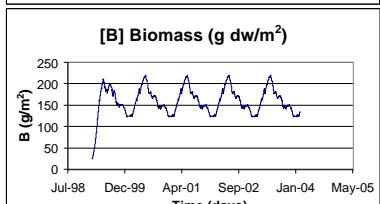
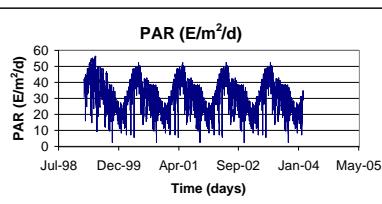
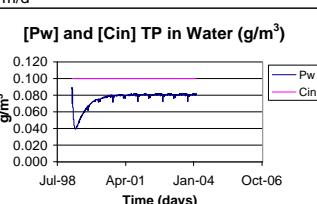
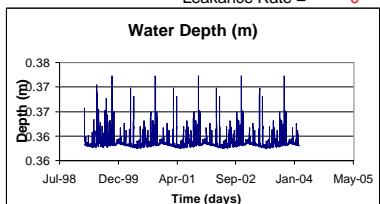
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0** m/d

Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Initial B = **23.8** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90o V-notch**  
 Weir Width = **1** ft  
 Note: User inputs in red

CELL	TC 13
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.100
TPout (g/m <sup>3</sup> )	0.076
k <sub>1TP</sub> (m/y)	5.99
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0761
B (g AFDW/m <sup>2</sup> )	159.38
P <sub>B</sub> (g/m <sup>2</sup> )	0.7794
P <sub>B</sub> /B (mg/kg AFDW)	5004.3
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.3875
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	6.0746
H =	0

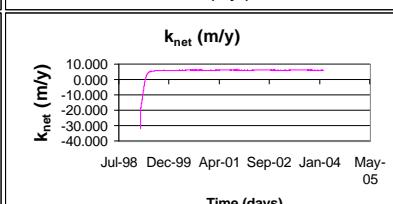
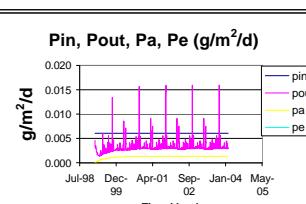
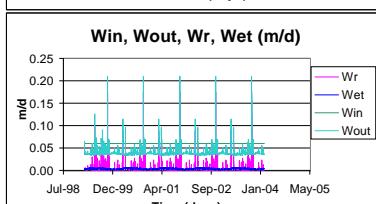
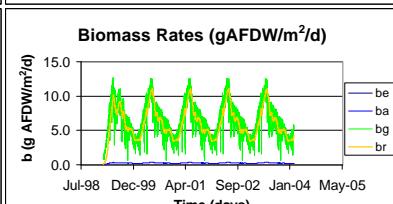
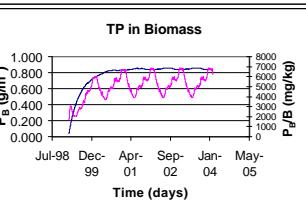
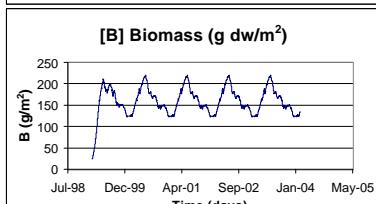
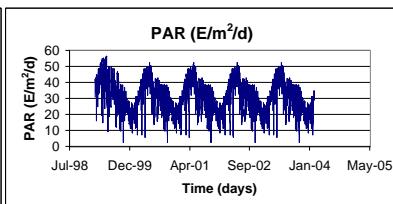
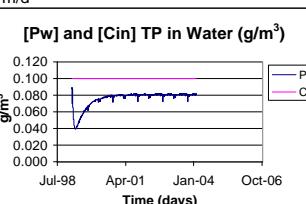
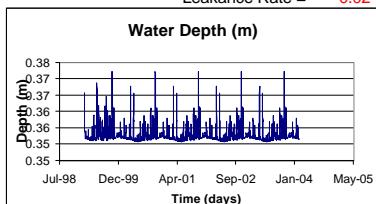
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = 14.5 ft  
 Starting Stage = 15.7 ft  
 Wetland Area at grade = 2240 m<sup>2</sup>  
 Volume below grade = 0 m<sup>3</sup>  
 Leakance Rate = 0.02 m/d

Initial P<sub>w</sub> = 0.07 g/m<sup>3</sup>  
 Initial B = 23.8 g/m<sup>2</sup>  
 Initial P<sub>B</sub> = 0.0400 g/m<sup>2</sup>  
 Initial P<sub>L</sub> = 0.1200 g/m<sup>2</sup>

Time Step = 0.2 d  
 Weir Equation = 90° V-notch  
 Weir Width = 1 ft  
 Note: User inputs in red

CELL	TC 13
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.100
TPout (g/m <sup>3</sup> )	0.076
k <sub>1TP</sub> (m/y)	5.99
W (m)	0.3527
P <sub>w</sub> (g/m <sup>3</sup> )	0.0761
B (g AFDW/m <sup>2</sup> )	159.38
P <sub>B</sub> (g/m <sup>2</sup> )	0.7794
P <sub>B</sub> /B (mg/kg AFDW)	5004
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.3875
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	6.0746
H =	0

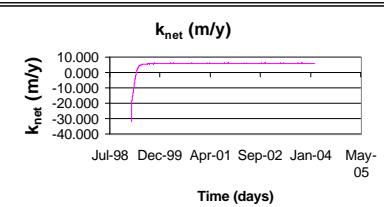
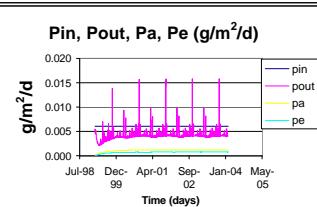
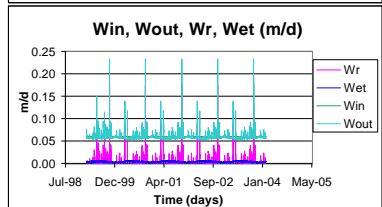
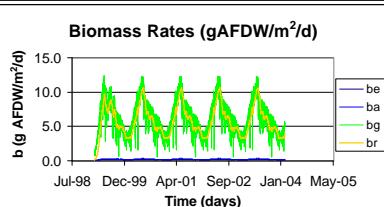
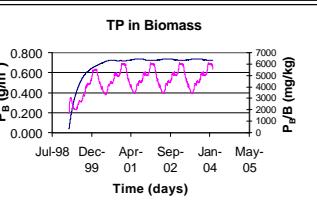
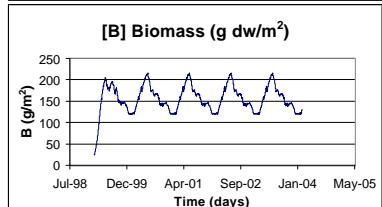
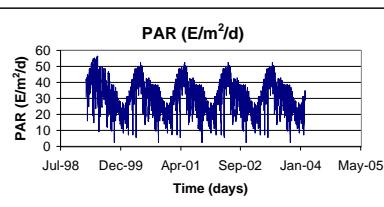
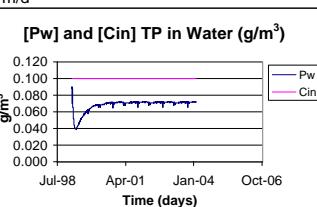
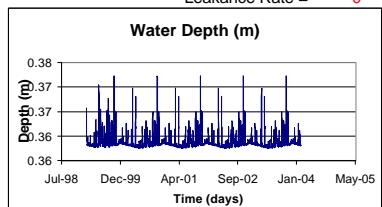
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0** m/d

Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Initial B = **23.8** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90o V-notch**  
 Weir Width = **1** ft  
 Note: User inputs in red

CELL	TC 13
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TPin (g/m <sup>3</sup> )	0.100
TPout (g/m <sup>3</sup> )	0.068
k <sub>1TP</sub> (m/y)	8.33
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0684
B (g AFDW/m <sup>2</sup> )	155.12
P <sub>B</sub> (g/m <sup>2</sup> )	0.6805
P <sub>B</sub> /B (mg/kg AFDW)	4496.7
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.2187
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	5.76
H =	0.001

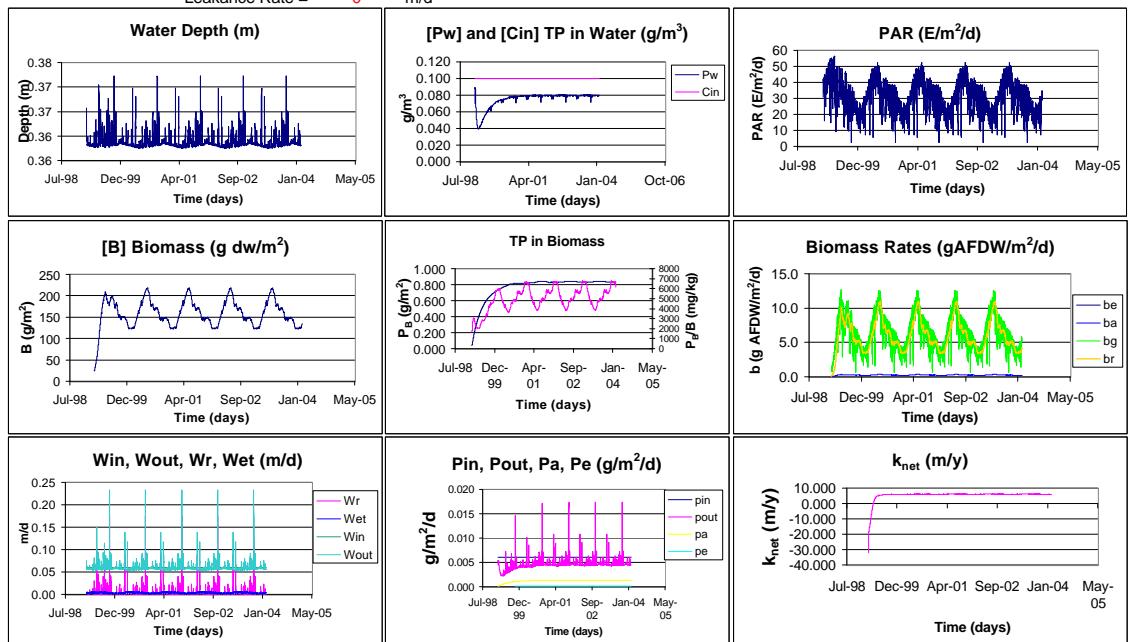
**Periphyton Stormwater Treatment Area (PSTA) Research and Demonstration Project - CH2MHILL**  
**PSTA Phase 2 Phosphorus Forecast Model**

Wetland grade = **14.5** ft  
 Starting Stage = **15.7** ft  
 Wetland Area at grade = **2240** m<sup>2</sup>  
 Volume below grade = **0** m<sup>3</sup>  
 Leakance Rate = **0** m/d

Initial P<sub>w</sub> = **0.07** g/m<sup>3</sup>  
 Initial B = **23.8** g/m<sup>2</sup>  
 Initial P<sub>B</sub> = **0.0400** g/m<sup>2</sup>  
 Initial P<sub>L</sub> = **0.1200** g/m<sup>2</sup>

Time Step = **0.2** d  
 Weir Equation = **90o V-notch**  
 Weir Width = **1** ft  
 Note: User inputs in red

CELL	TC 13
TP <sub>in</sub> (g/m <sup>3</sup> )	fixed 0.100
HLR (cm/d)	fixed 6.0
DEPTH (ft)	fixed 1.0



Parameter	P.O.R Avg
HLR (m/y)	21.90
TP <sub>in</sub> (g/m <sup>3</sup> )	0.100
TP <sub>out</sub> (g/m <sup>3</sup> )	0.075
k <sub>1TP</sub> (m/y)	6.24
W (m)	0.3588
P <sub>w</sub> (g/m <sup>3</sup> )	0.0752
B (g AFDW/m <sup>2</sup> )	158.96
P <sub>B</sub> (g/m <sup>2</sup> )	0.7683
P <sub>B</sub> /B (mg/kg AFDW)	4947
b <sub>q</sub> (g AFDW/m <sup>2</sup> /d)	6.3706
b <sub>r</sub> (g AFDW/m <sup>2</sup> /d)	6.0427
H =	0.0001

**APPENDIX G**

## **Model Simulation Output Graphs**

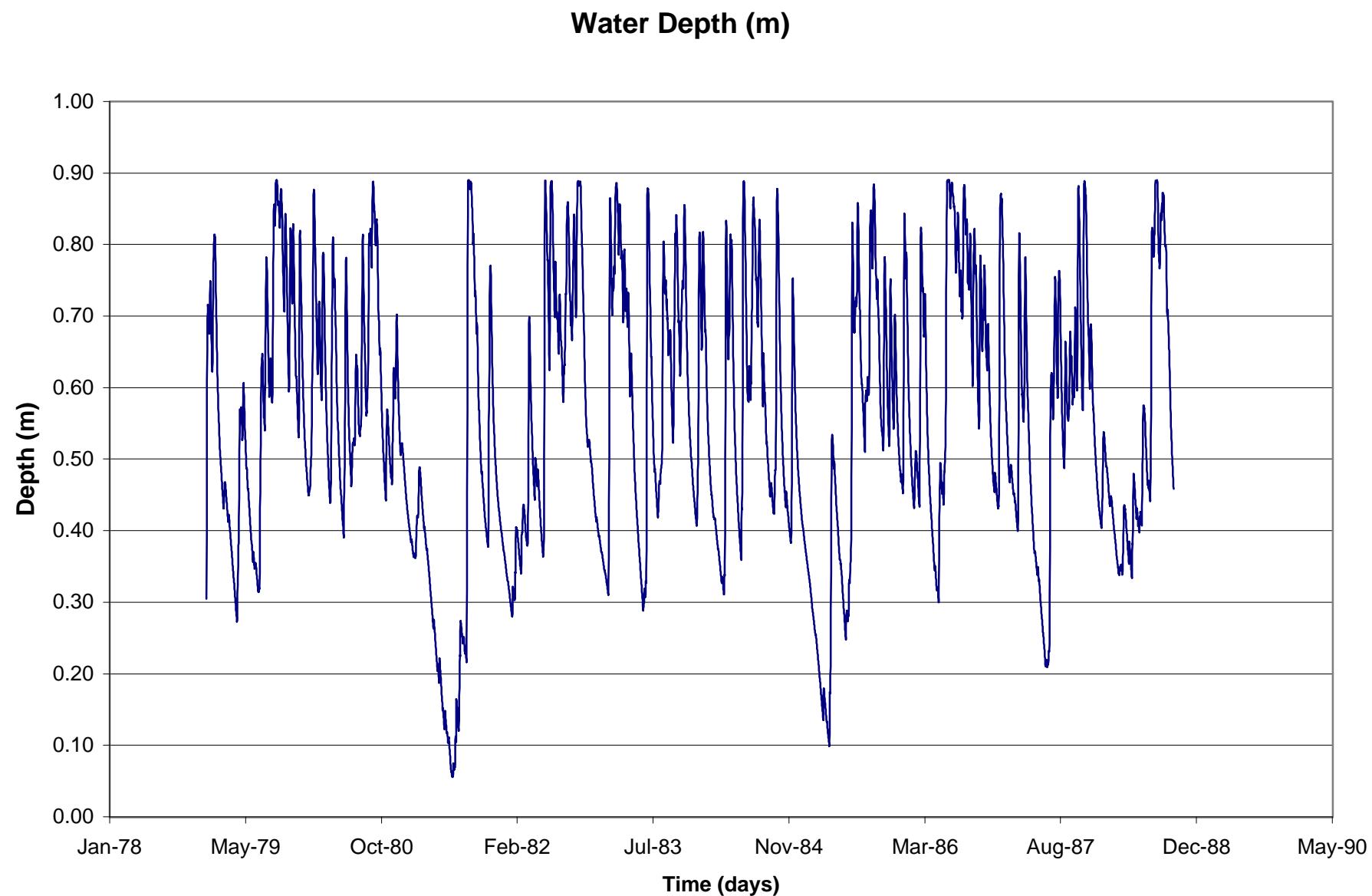
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## **APPENDIX G**

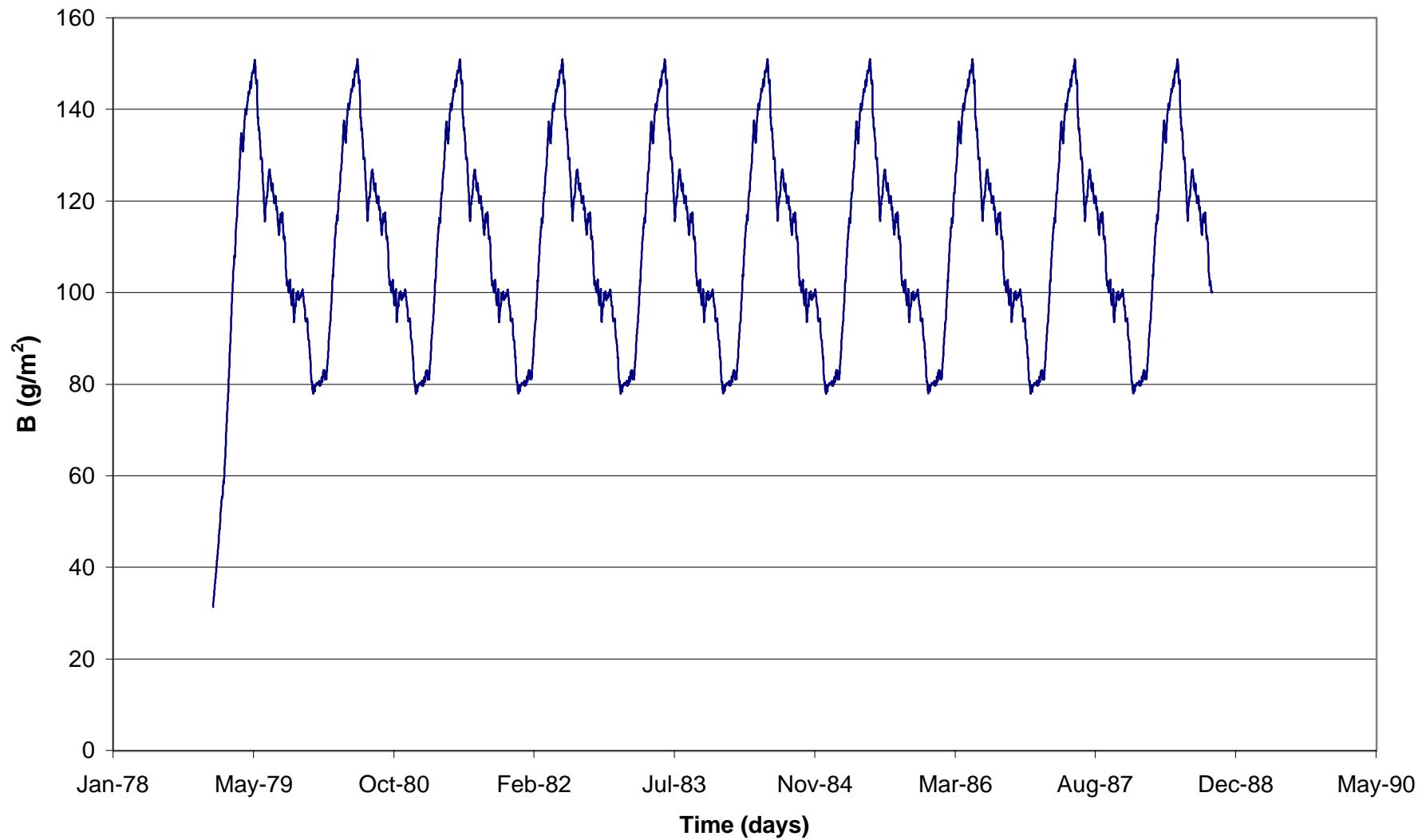
# **Model Output Graphs**

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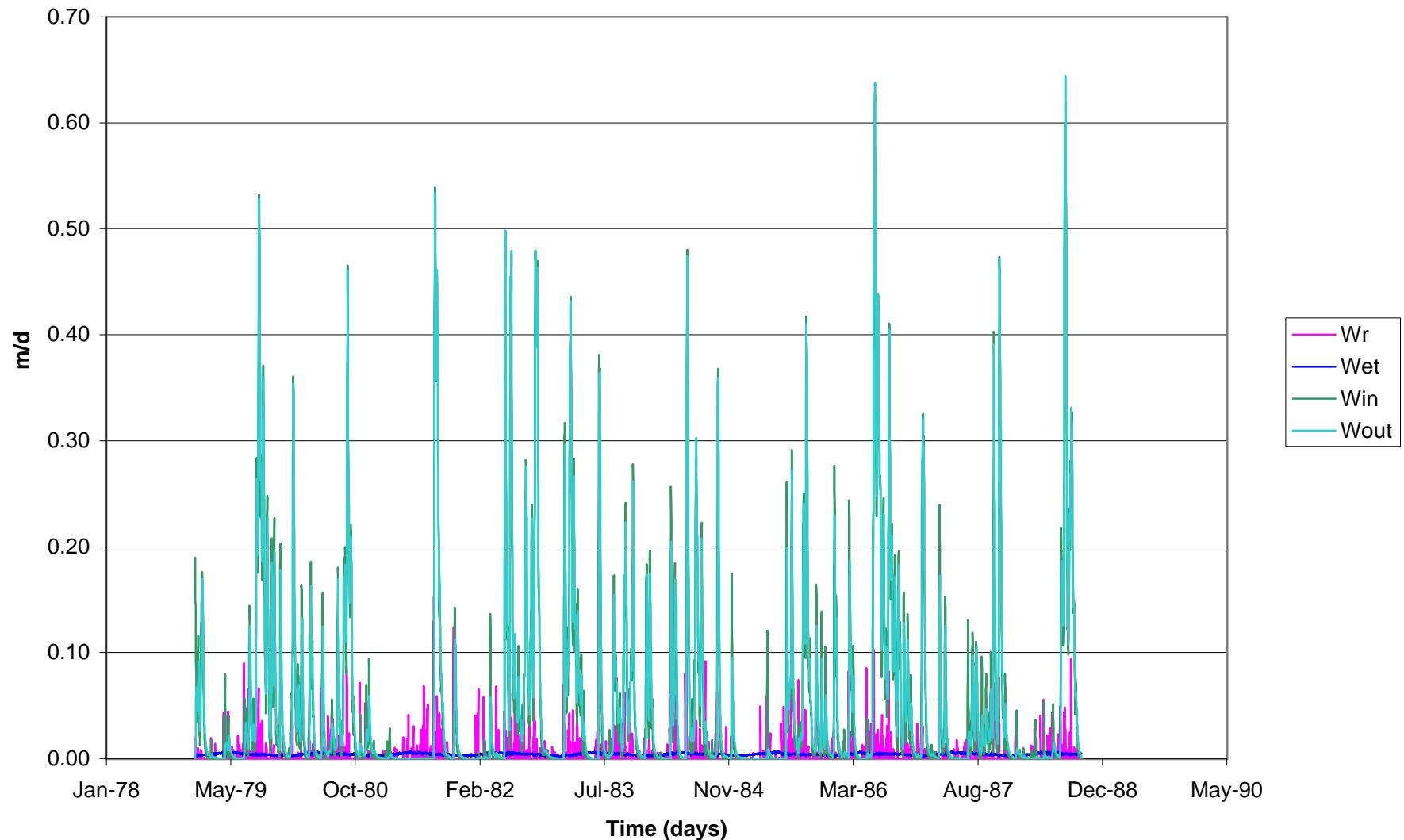
This appendix provides detailed output graphs for the PSTA Phase 2 model simulation using a 10-year post-STA 2 data set.



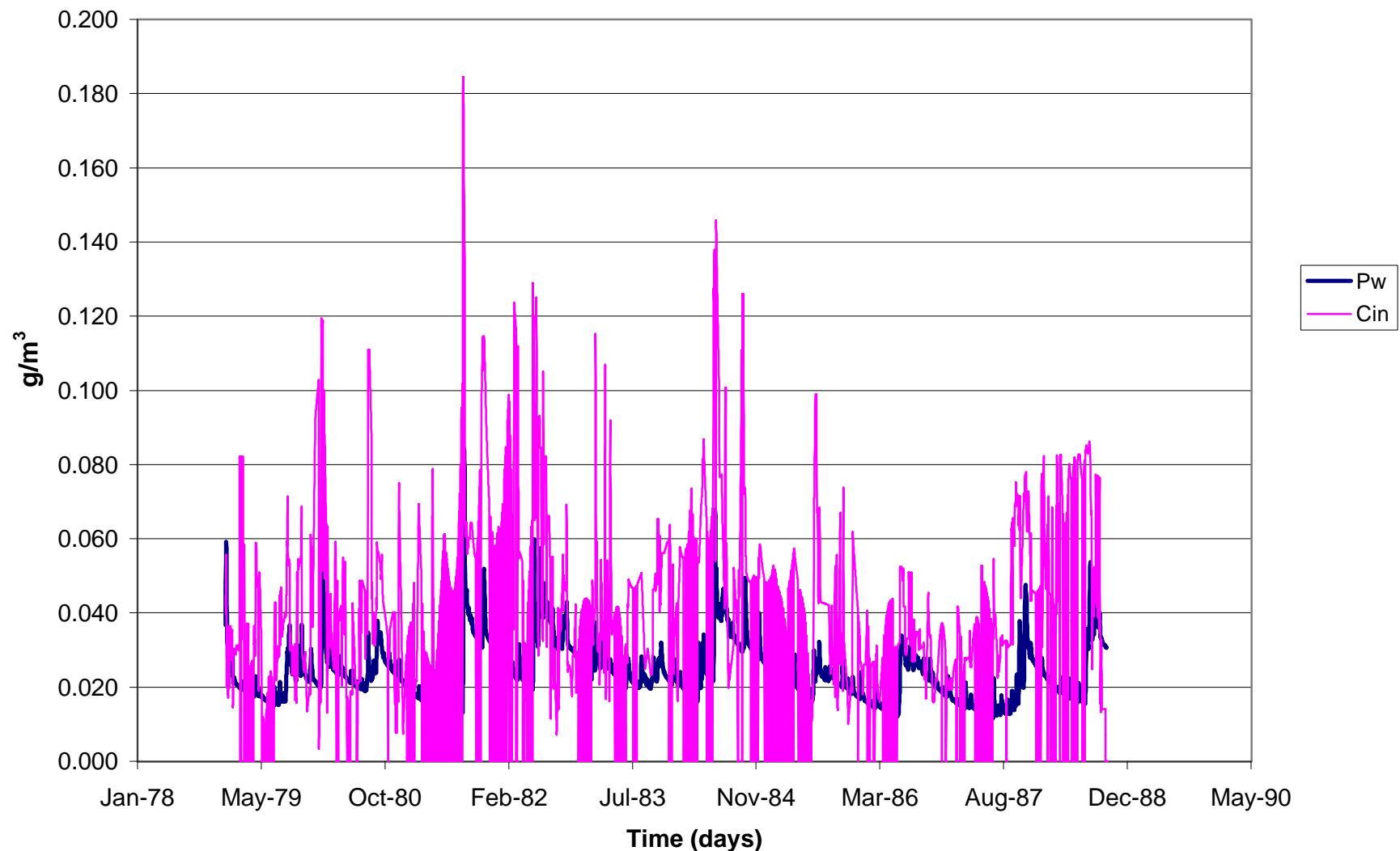
**[B] Biomass (g dw/m<sup>2</sup>)**

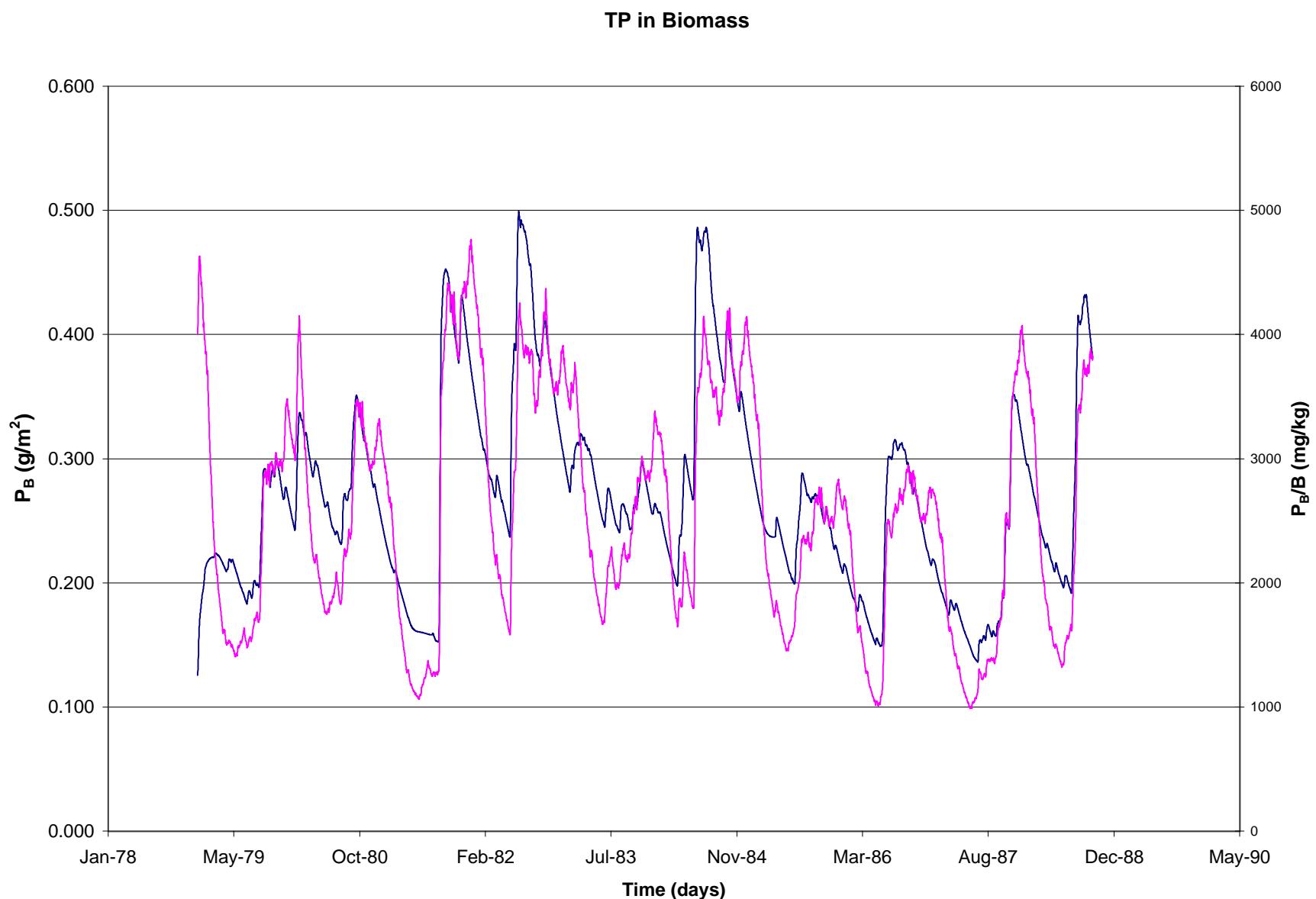


## Win, Wout, Wr, Wet (m/d)



### [Pw] and [Cin] TP in Water ( $\text{g/m}^3$ )





## Pin, Pout, Pa, Pe ( $\text{g}/\text{m}^2/\text{d}$ )

